DOE/NASA CONTRACTOR REPORT

DOE/NASA CR-161763

SOLAR SPACE HEATING INSTALLED AT KANSAS CITY, KANSAS - FINAL REPORT

Prepared from documents furnished by

Ducat Investments Inc.
Kansas City, Kansas

Under DOE Contract EG-77-A-01-4079

Monitored by

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George C. Marshall Space Flight Center, Alabama 35812

For the U.S. Department of Energy

(NASA-CR-161763) SOLAR SPACE HEATING INSTALLED AT KANSAS CITY, KANSAS Final Report (Ducat Investments, Inc.) 135 p HC A07/MF A01 CSCL 10A

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Solar Energy

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I FOREWORD

The National Program for Solar Heating and Cooling is being conducted by the Department of Energy as mandated by the Solar Heating and Cooling Demonstration Act of 1974. The overall goal of the Federal Demonstration Program is to assist in the establishment of a viable solar industry and to stimulate its growth so as to achieve a substantial reduction in fossil fuel use through widespread use of solar heating and cooling applications. An analysis and synthesis of the information gathered through this program will be disseminated in site-specific reports and summary documents. They include:

- Solar Project Description
- Design/Construction Contractor Final Report
- Project Costs
- Maintenance and Reliability
- Operational Experience
- System Performance Evaluation
- Monthly Progress Reports

The Solar Project Description is prepared for the purpose of documenting the project description in the "as-built" state. Information contained herein has been extracted from data collected during site visits and from reference documents such as the project proposal, designers' specifications, contractors' submittals, manufacturers' literature, photographs, "as-built" drawings, and other project documentation as available. The remaining reports in this series will rely on the Solar Project Description for specific site details.

II EXECUTIVE SUMMARY

The following is a brief summary of the solar energy system at the Ducat Investments, Inc. warehouse in Kansas City, Kansas. Major Features of this system includes:

- Collector - Air, double glaze, flat plate
- Freeze protection - None required
- Application - Heating
- Storage - None
- New/Retrofit - New
- Performance Evaluation Instrumentation - Yes
- Site-Specific Features - No storage

The solar energy system was constructed with the new 48,800 square feet warehouse to heat the warehouse area of about 39,000 square feet while the auxiliary energy system heats the office area of about 9,800 square feet.

The building has 20 bays, and each bay has its own solar system. The 20 collectors for each bay are mounted in a single row. These collectors are double glazed, flat plate collectors and are mounted at 53° to the horizontal.

Air is heated either through the collectors or by the electric resistance duct coils. Return air is drawn through the collectors and circulated back into the warehouse space. There is no storage for this system.

The solar energy system has been operational since April 1979. It has been fully instrumented for performance evaluation and integrated into the National Solar Data Network.

III KEY WORD ABSTRACT

Application--Space heating air system.

Collector Type--Flat plate air.

Collector Manufacturer--Solaron Corporation.

Collector Area--7,800 square feet.

Storage--Warehoused material and building shell mass.

Building Load--888.12 (Mill BTU).

BTU's Produced--(Estimated) 499.12 (Mill BTU).

Architect/General Contractor--Midgley, Shaughnessy, Fickel and Scott/ A. L. Huber & Sons Construction.

Solar System Contractor--City Wide Heating & Cooling Company, Inc.

IV INTRODUCTION

From the outset the Du-Cat Office and Warehouse had been planned to have the flexibility to accommodate the space needs of future tenants and to offer a real savings in heating and cooling operational costs. The building is 100 feet deep and 488 feet long with a floor to steel joist height of 22 feet. The long axis of the building is from north to south. The collectors are arrayed on the roof of the building in 20 rows with 20 collectors per row. The original solar system was designed to meet a percentage of the heating requirements for the warehouse portion of the building only. It is estimated that the solar system will supply 56.2% of the heating requirements of the warehouse area. The warehouse was designed to take up 39,000 square feet of the building. The building envelope is well insulated in that it has an R-20 roof and R-11 sidewall. Comparatively, the energy required to heat the building without solar will be 30-35 percent less than similar buildings built under normal construction standards in the Kansas City area.

V DESIGN PHILISOPHY

The solar system is designed under the major premises of simplicity and flexibility. In designing an office warehouse facility for the needs of a future unknown leasee, the space designer must be flexible in that he can only assume the space requirements that a tenant will need. For example, the building may accommodate one or ten leasees. One leasee may require 20% office space and 80% warehouse space, while another may require just the opposite. Therefore, the space designer can only provide a very tentative floor plan which will lend itself to the probable needs of a tenant. So is the case with the mechanical engineer who must also remain flexible in his design.

However, in designing under a grant situation one must be relatively concrete in the design in which he intends to submit. In order to be firm in design yet flexible in application the warehouse area was split into 20 24 foot by 80 foot bays which assumes a normal warehouse/office space requirement. Since the heating demands of the office and those of a warehouse were different and that simplicity in solar design was paramount, it was determined that the offices be heated and cooled conventionally while the warehouse be heated with a primary solar system.

If we assume that there will be multiple tenants then we must also assume, for metering and demand purposes, that each tenant will need to control his heating as required. Therefore, 20 individual solar systems were designed, each with its individual thermostat control. The 2-stage space thermostat will dictate the heating demand and a simple differential temperature controller will acknowledge the availability or unavailability of solar heat.

The collectors on the roof are air collectors which are manifolded internally and externally with supply and return ductwork. In the ducting system there is one blower, two motorized control dampers, and one electric resistance heating section to supply back up heat. The control dampers are placed in the ductwork so that air can be drawn through the collectors via the blower into the supply ductwork in the interior of the warehouse, or the air may be rerouted to by-pass the collectors and allow the return air to be heated directly by the electric resistance heater.

There is no provision for storage in the system other than the mass of whatever materials are stored plus the mass of the building itself. There are a number of reasons why storage was eliminated from the design. First: the normal storage rock vessels are very space consuming and would take up valuable warehouse space. Second: when storage is eliminated the need for more extensive ductwork and controls are eliminated. Third: massive storage requirements may not be necessary due to the fact that a warehouse is normally manned about eight hours during the day. Therefore, nocturnal demand is minimized and hopefully the heating requirement at night would be partially satisfied by the radiant heat given off by the warehoused materials which had absorbed much of the daytime heat. Fourth: if this warehouse is successfully heated without storage, it may be that warehouses may wish to follow suit which could be one simple and inexpensive means of heating voluminous spaces on a retrofit basis without extensive redesign and structural changes.

VI SITE AND BUILDING DESCRIPTION

Site Description

- Special topographical or climatic conditions - None
- Latitude - 39°
- Annual degree days (55°F base)
    - o Heating - 5,357
    - o Cooling - 1,287
    - o Data location - Kansas City, Kansas
    - o Data reference - "Input Data for Solar Systems" U.S. Department of of Energy, Interagency Agreement No. E(49-26)-1041, November,1978
- Average horizontal insolation
    - o January - 648 Btu/ft^2/day
    - o July - 2,102 Btu/ft^2/day
    - o Data location - Kansas City, Kansas
    - o Data reference - "Input Data for Solar Systems," U.S. Department of Energy, Interagency Agreement No.E(49-26)-1040, November, 1978.
- Site topographic description - Flat
- Shading - None

Building Description

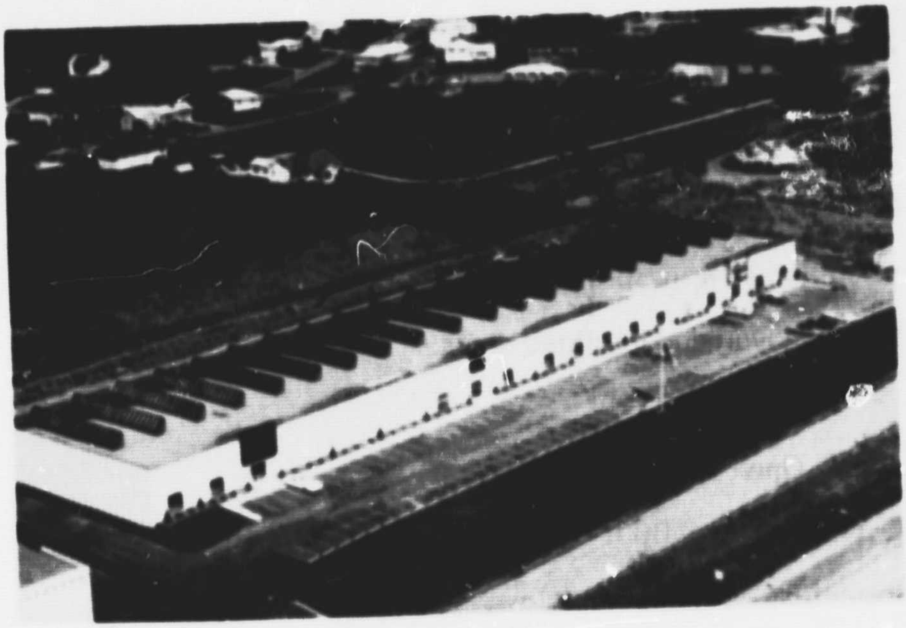
- Occupancy - Warehouse and office
- Total area - 48,800 ft^2
    - o Warehouse - 39,000 ft^2
    - o Office - 9,800 ft^2
- Solar conditioned area - Warehouse area only, 39,000 ft^2
- Number of stories - One
- Roof slope - Flat

Structure

- Walls
    - o Type - Load bearing masonry wall
    - o Exterior finish - Concrete block
    - o Insulation - 1½ in. sprayed cellulose, R-11
    - o Doors - Overhead insulated doors
- Roof
    - o Type - Open web steel joists
    - o Exterior finish - Built-up roof with gravel finish
    - o Insulation - 5 in. of fiberglass, R-20

Mechanical System

- Heating
    - o Solar - Air system with no storage
    - o Auxiliary - Electric resistance heater elements
    - o Distribution - Duct system
- Air Handling Unit
    - o Manufacturer - Carrier
    - o Model No. - 40FS160300

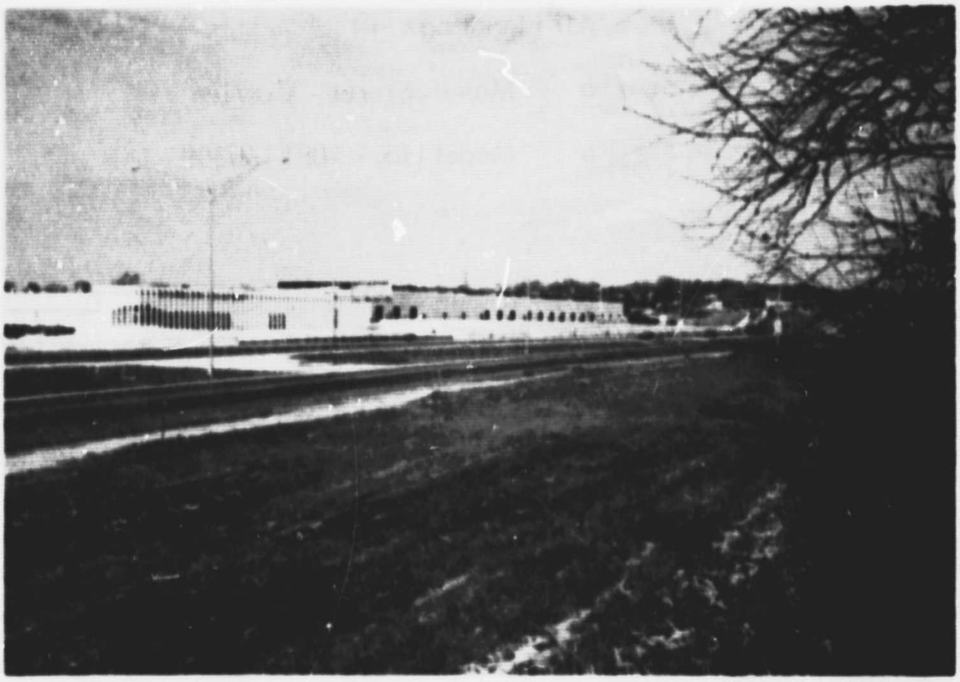


Photograph 1

Aerial view of
Du-Cat warehouse
showing roof mounted
collectors

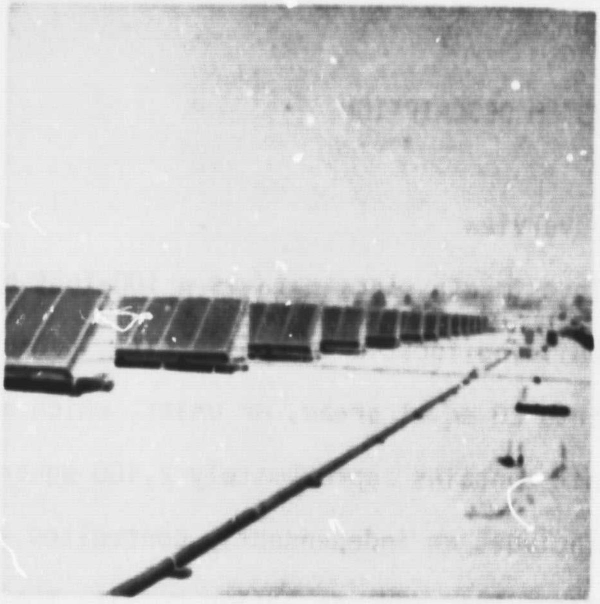
Photograph 2

Ground view of
Du-Cat warehouse



Photograph 3

Collector rows mounted on roof



Photograph 4

(Ceiling mounted) Duct work and air handling unit

VII SOLAR SYSTEM DESCRIPTION

A. General Overview

The Du-Cat Investments, Inc. site is a 100-foot by 488-foot steel framed commercial building located in Kansas City, Kansas. This leasable building is divided into 20 equal areas, or units, which are designated units 1 through 20. Each unit contains approximately 2,400 square feet of conditioned space, and includes an independently controlled solar energy and auxiliary heating system. This modular design permits the flexibility of combining multiple units to form offices and warehouses of various size floor areas as required by a tenant. Although there are 20 independently controlled systems installed in the building, only four systems, units 8, 12, 17, and 20, are instrumented for collection of data.

For each unit, solar energy is collected by an array of flat-plate collectors with a gross area of 400 square feet. The collectors, manufactured by Solaron Corporation, face three degrees east of south at an angle of 53 degrees from the horizontal. Solar heated air flows directly from the collectors to the conditioned space. When solar energy is not available, auxiliary heating is provided by a 14-kilowatt resistance heater within the air-handler unit (AHU).

B. Collector Subsystem

The collector array is in 20 rows with 20 collector panels in each row. Each one of the 20 warehouse bays is individually heated by a collector row. The office area in each bay is heated by conventional HVAC units.

Collectors

- Type - Double glazed flat plate collectors
- Manufacturer - Solaron
- Model No. - 2000
- Number - 400
- Collector orientation - 3^{o} east of south
- Tilt angle - 53^{o} to the horizontal
- Gross area - 7,800 ft^2
- Net area - 7,000 ft^2

Array configuration - 20 rows of 20 collector panels each; see figure VII for typical row.

Collector enclosure

- Frame material - 24 gage steel
- Overall size - 78 in. x 36 in. x 7¼ in.
- Gross area - 19.5 ft^2
- Filled weight - 153 lb

Glazing

- Number - Double
- Material - Fourco clearlite low iron tempered glass
- Thickness - 0.125 in.

- Transmittance - 90 percent
- Reflectance - 4 percent

Absorber plate

- Type - Flat plate
- Material - 28 gage steel sheet
- Coating and application - Baked-on flat black coating
- Absorptance - 94 percent
- Emittance - 85 percent

Collector Support (see figure VIII)

The collectors are attached to welded steel angle triangular supports. The supports are welded to metal legs that protrude through the roof in pitch pockets to metal base plates. The base plates are welded to the metal bar ceiling joist. The north side of the collector support is covered with metal siding. The steel angle supports are 6 feet apart.

C. Storage Subsystem - Not applicable; there is no storage.

D. Energy-to-Load Subsystem

General Description - Space heating is provided for each bay by circulating air from the warehouse through the collector bank. The air is passed through an air handling unit with a single stage electric resistant heater before it is sent back to the warehouse.

Space Heating

- Ducting - Steel
- Air handling unit
  - Manufacturer - Carrier
  - Model No. - 40FS160300
  - Flow rate - 1000 ft^3/min

- Power - 0.32 Hp

- Electric resistant heater element
    - Manufacturer - Indeeco
    - Model No. - QUA
    - Output - 15 KW
- Dampers - Manufactured by Honeywell

E. Controls Subsystem

General Description - The solar energy system may operate in two modes. Figure IV shows the system for space heating from the collectors. The collector absorber plate temperature must exceed the warehouse air temperature by 33°F before the mode is activated. The solar system will continue to operate until the space heating demand has been met or the temperature differential between the collector absorber plate and the air in the warehouse is less than 21°F. A two-stage thermostat is used to maintain the warehouse at a set temperature. If the solar system is unable to maintain the warehouse at the set temperature, the two stage thermostat activates the electrical resistance duct coils to provide for auxiliary heating. Figure V shows the auxiliary space heating mode when the collector absorber plate temperature is less than 21°F warmer than the warehouse air temperature.

The solar energy commercial demonstration project for the Ducat Investments, Inc. warehouse is represented in The Site Plan figure I. The major components of the system include 7,800 ft^2 of Solaron collectors, an air handling unit, and an auxiliary electric furnance.

Subsequent sections describe the collector, energy-to-load, auxiliary energy, and control subsystems. Figure II shows a overall system schematic. Appendices A and B present a glossary and legend of symbols.

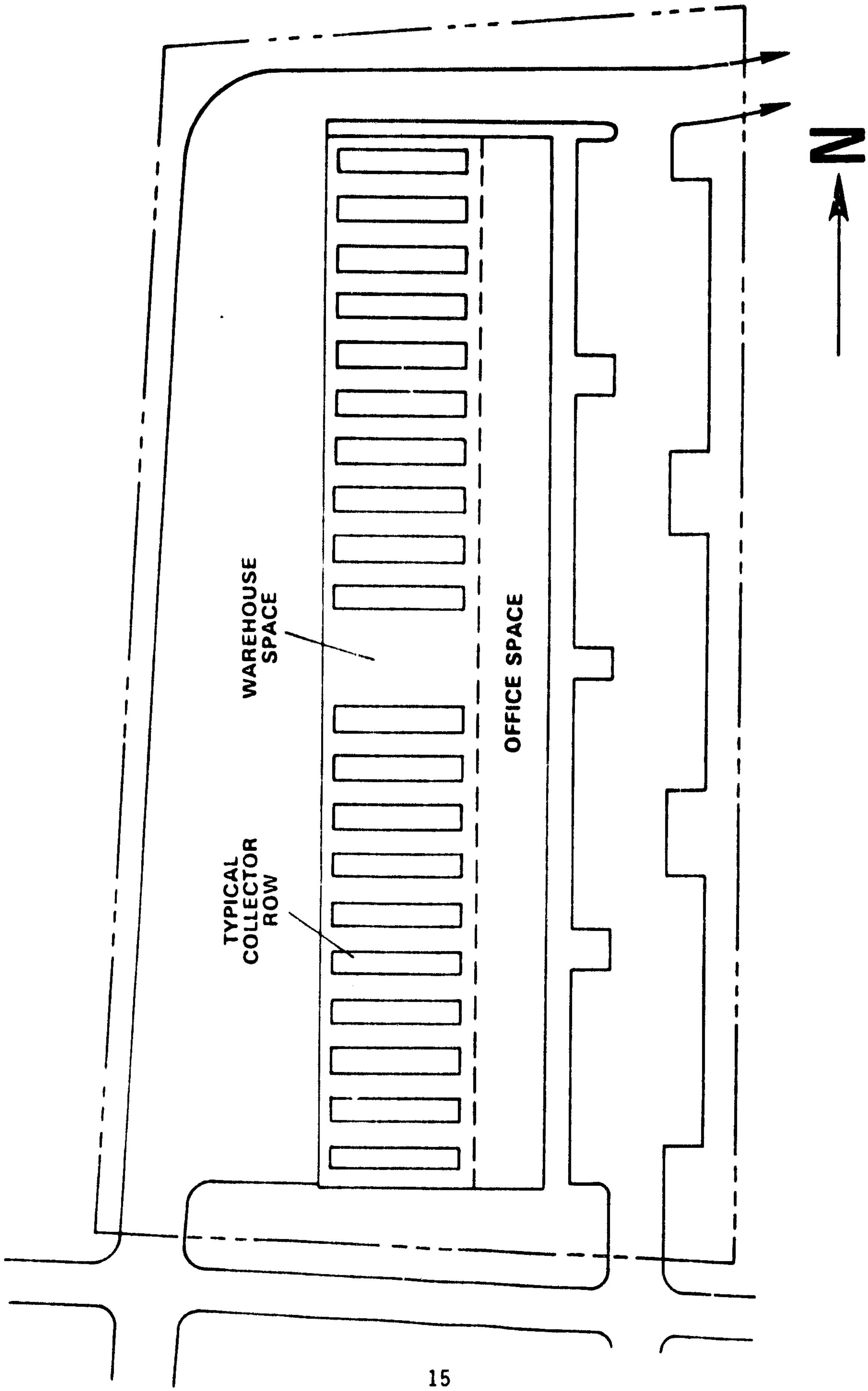


Figure I Site Plan

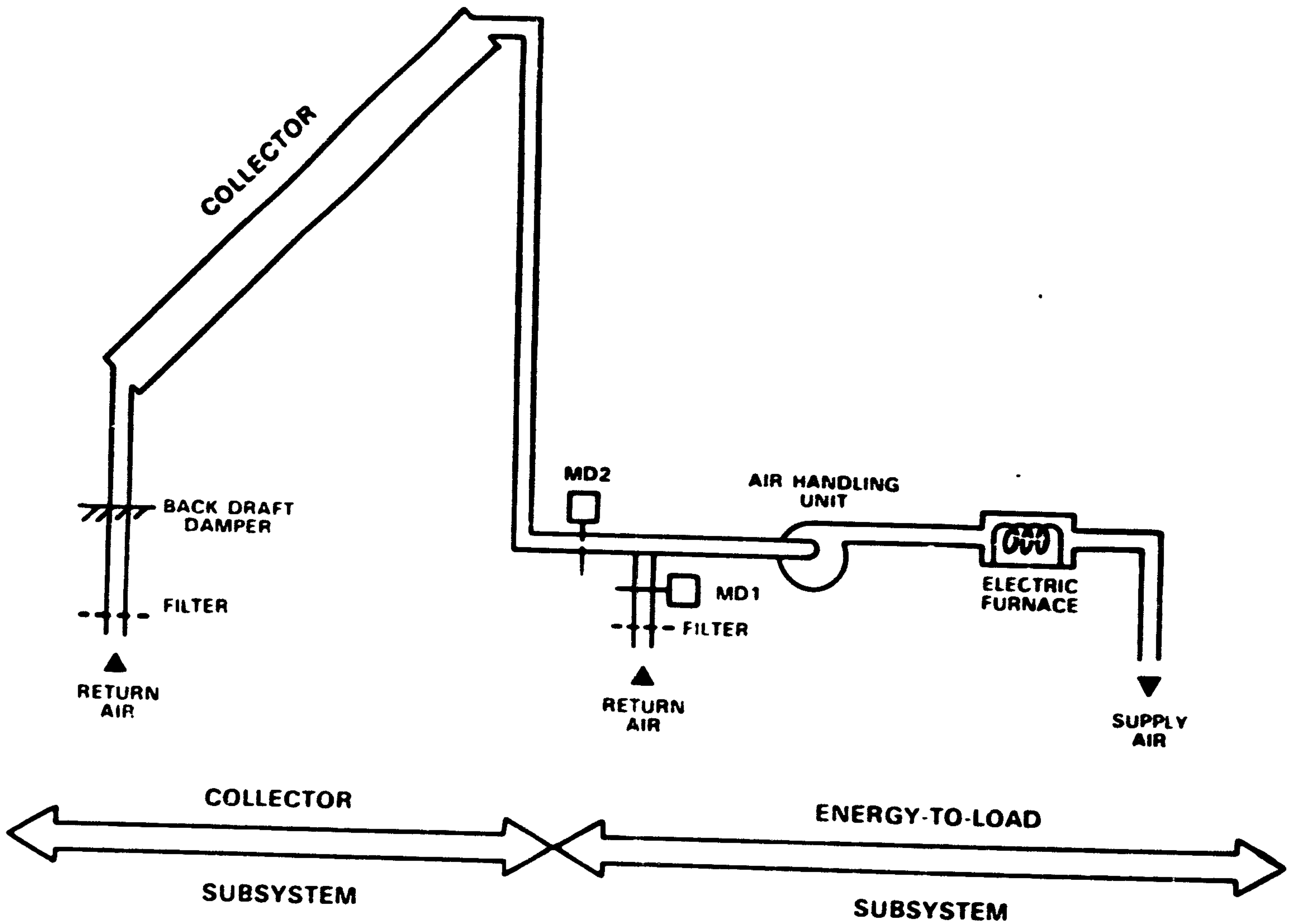


Figure II Overall System Schematic

VIII SYSTEM OPERATING MODES

Of the total of 20 individual Solar Collection Systems, four systems are completely instrumented. These four systems cover bays 8, 12, 17 and 20. Figure III shows the instrumentation location for the temperature sensors, flow meters, and watt meters. The space heating system for each of the instrumented units (shown schematically in Figure III has three modes of operation.

A. Mode 1 - Space Heating (Solar Only): This mode is entered when the sensed air temperature inside one collector absorber channel exceeds the sensed building inside ambient temperature by 33°F, and a stage one heating demand exists. In this mode, motorized damper D1 is closed, damper D2 is open, fan F1 is activated, and the auxiliary heating is off. This mode is terminated when either additional heating is required, as sensed by the thermostat, or when the sensed collector air temperature no longer exceeds the sensed building ambient temperature by more than 21°F. This mode of operation is shown in Figure IV.

B. Mode 2 - Space Heating (Solar and Auxiliary): This mode is entered from Mode 1 when the thermostat indicates that additional heat is required, and the sensed collector absorber air temperature exceeds the building temperature by more than 21°F. In Mode 2 operation, motorized damper D1 is closed, motorized damper D2 is open, AHU F1 is activated, and the auxiliary resistance heater is on. Termination of this mode occurs when Mode 1 or 3 conditions are met or the space heating demand is satisfied. This mode of operation is shown in Figure V.

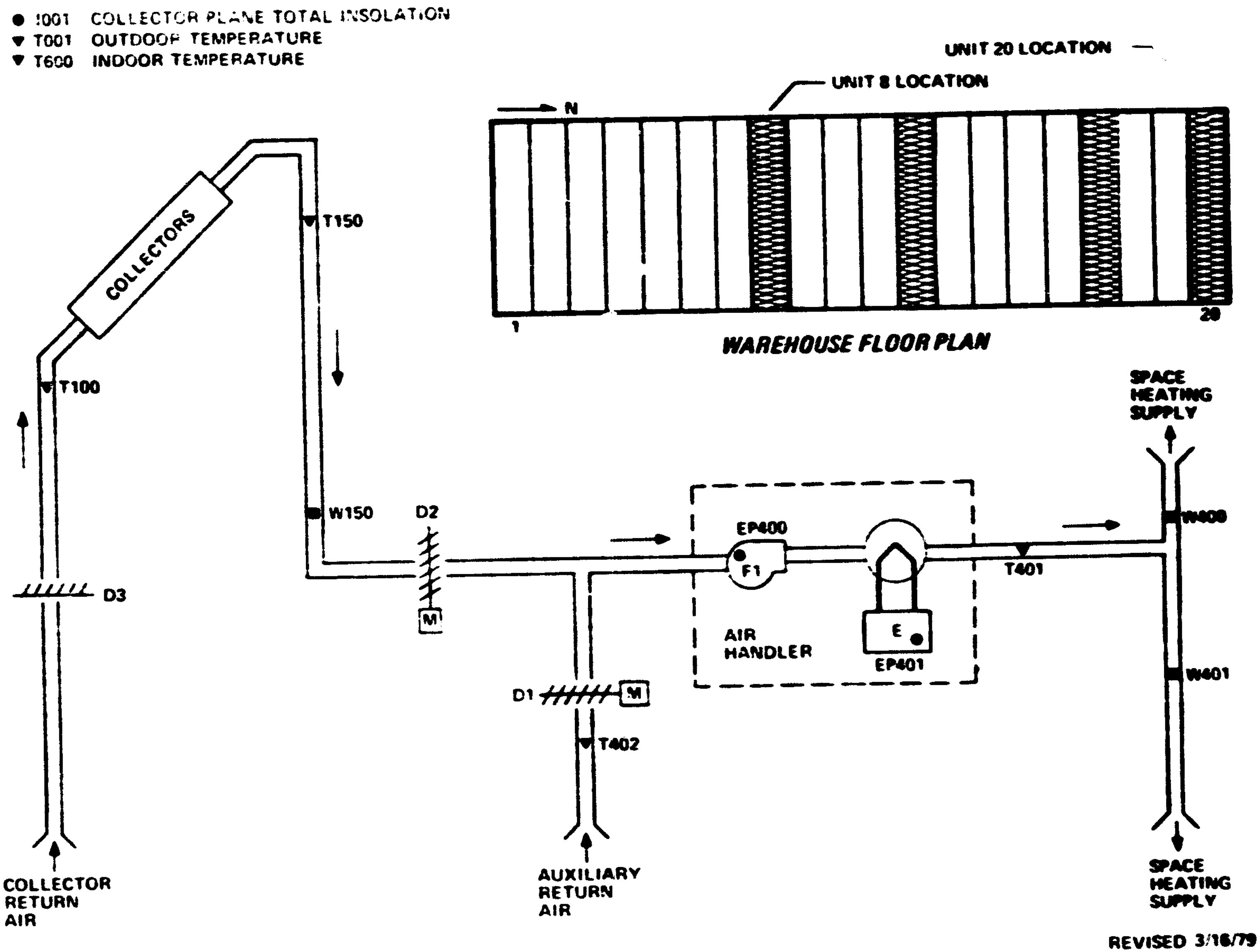


FIGURE III INSTRUMENTATION LOCATION

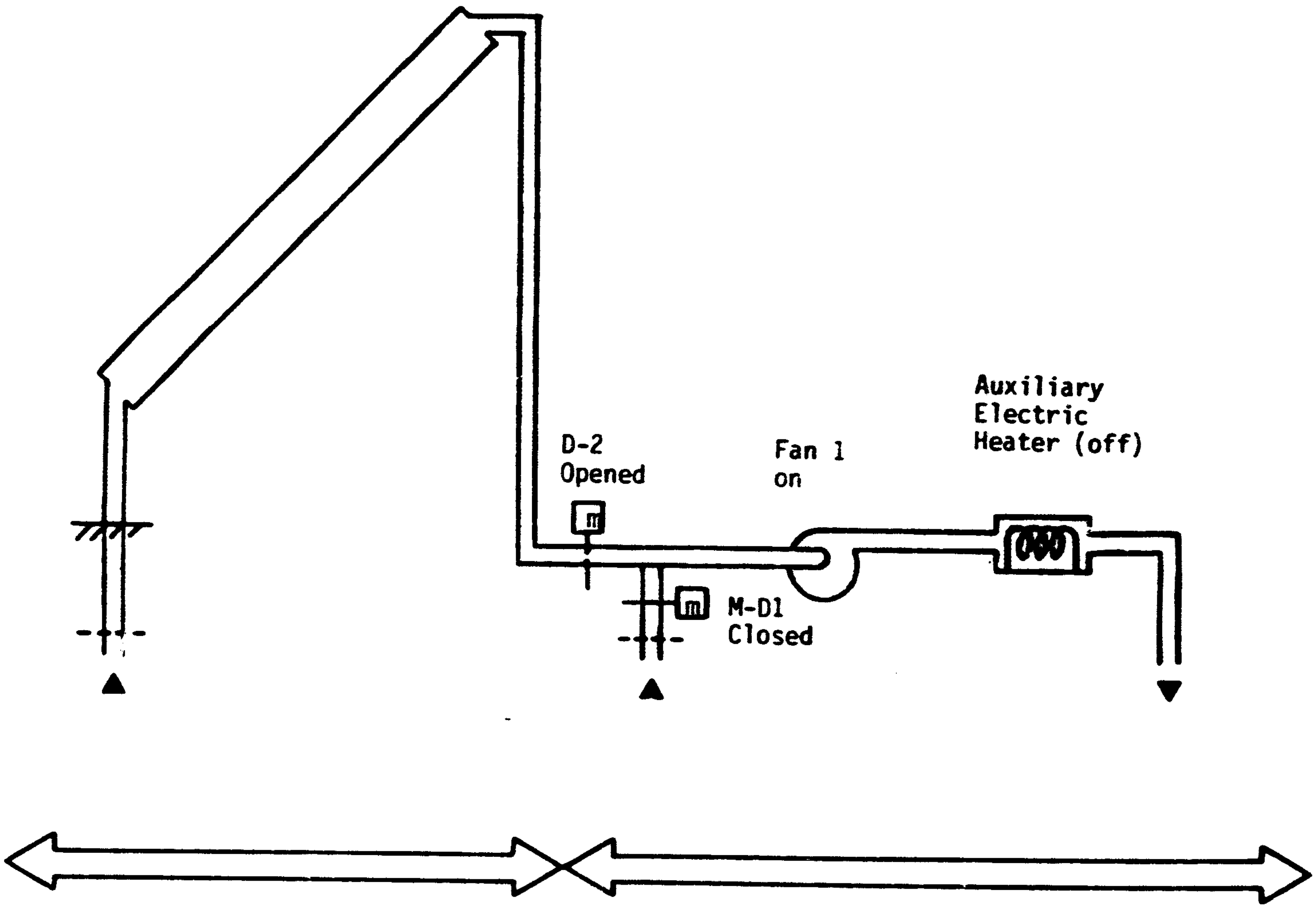


Figure IV Space Heating from Collector Mode 1 (solar only)

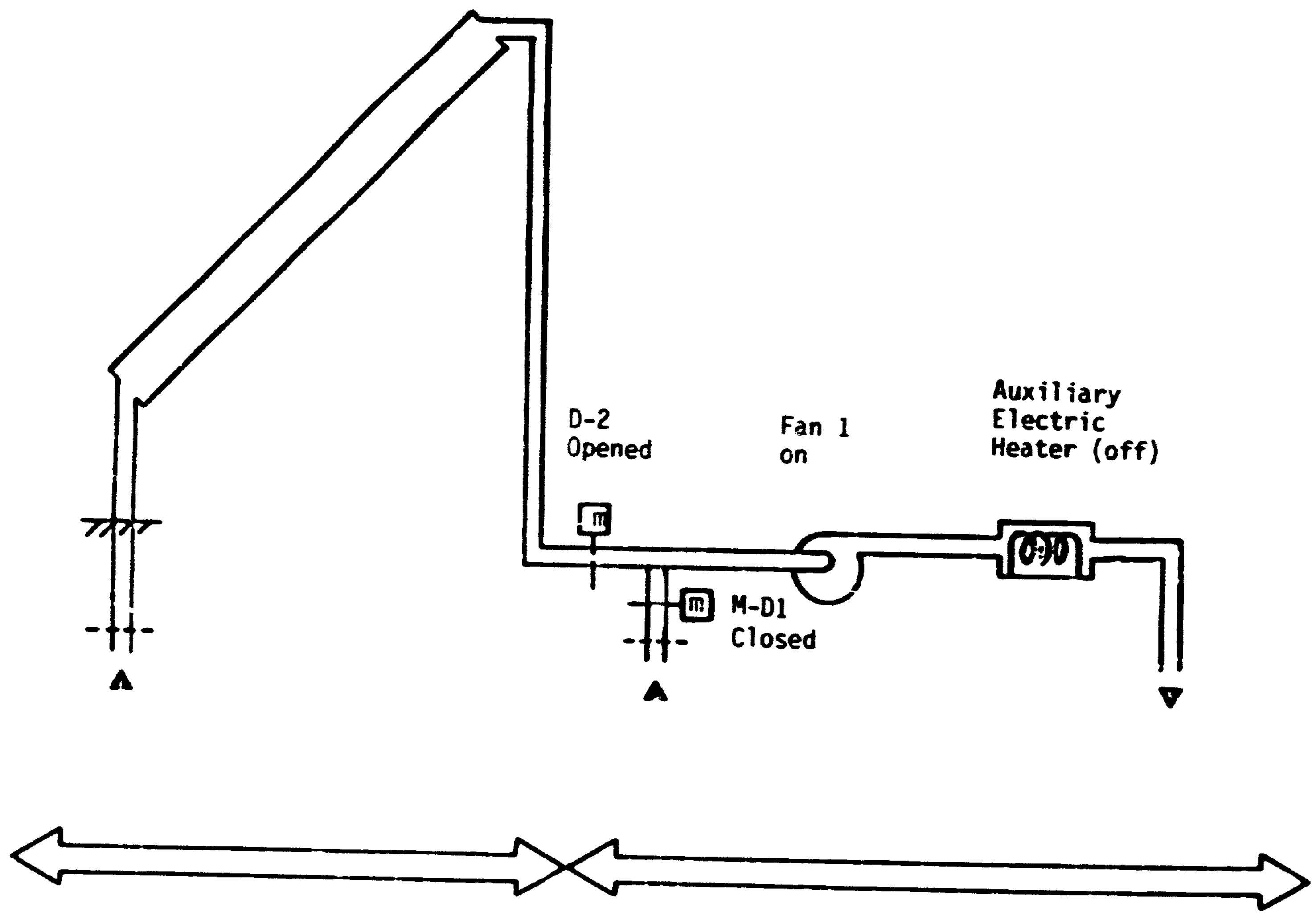


FIGURE V SPACE HEATING FROM COLLECTOR MODE 2 (SOLAR & ELECTRIC HEAT)

C. <u>Mode 3 - Space Heating (Auxiliary Only)</u>: This mode is entered from either Mode 1 or 2 when the sensed collector air temperature no longer exceeds the building temperature by 21°F. Space heating is provided entirely by the electrical resistance heater in the AHU. In this mode, motorized damper D1 is open and motorized damper D2 is closed. This mode of operation is depicted in Figure VI.

The collector air flow arrangement for a typical row of collectors is shown in figure VII while figure VIII shows a cross section of a typical collector row together with the support subsystem.

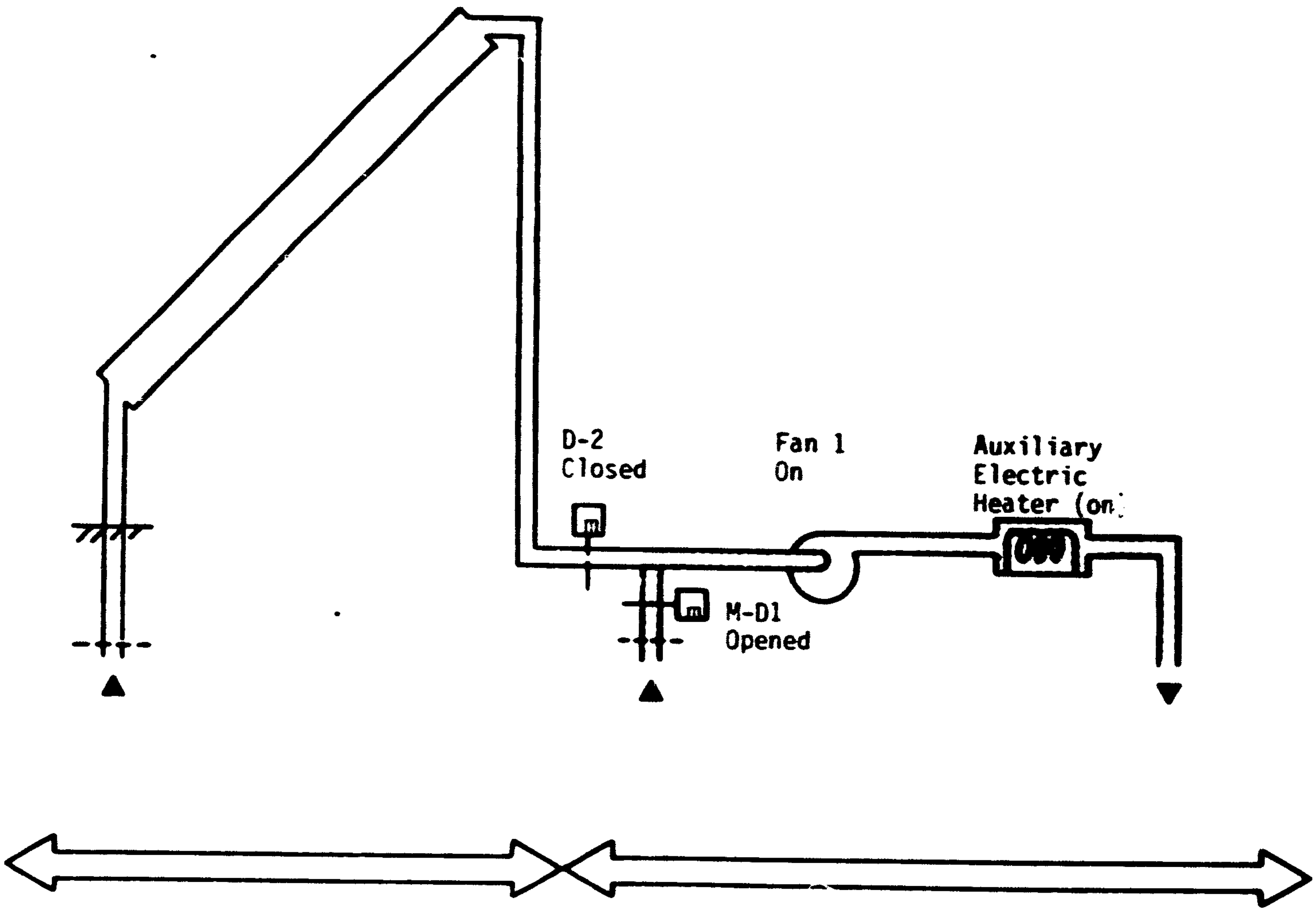


FIGURE VI AUXILIARY SPACE HEATING MODE (ELECTRIC ONLY)

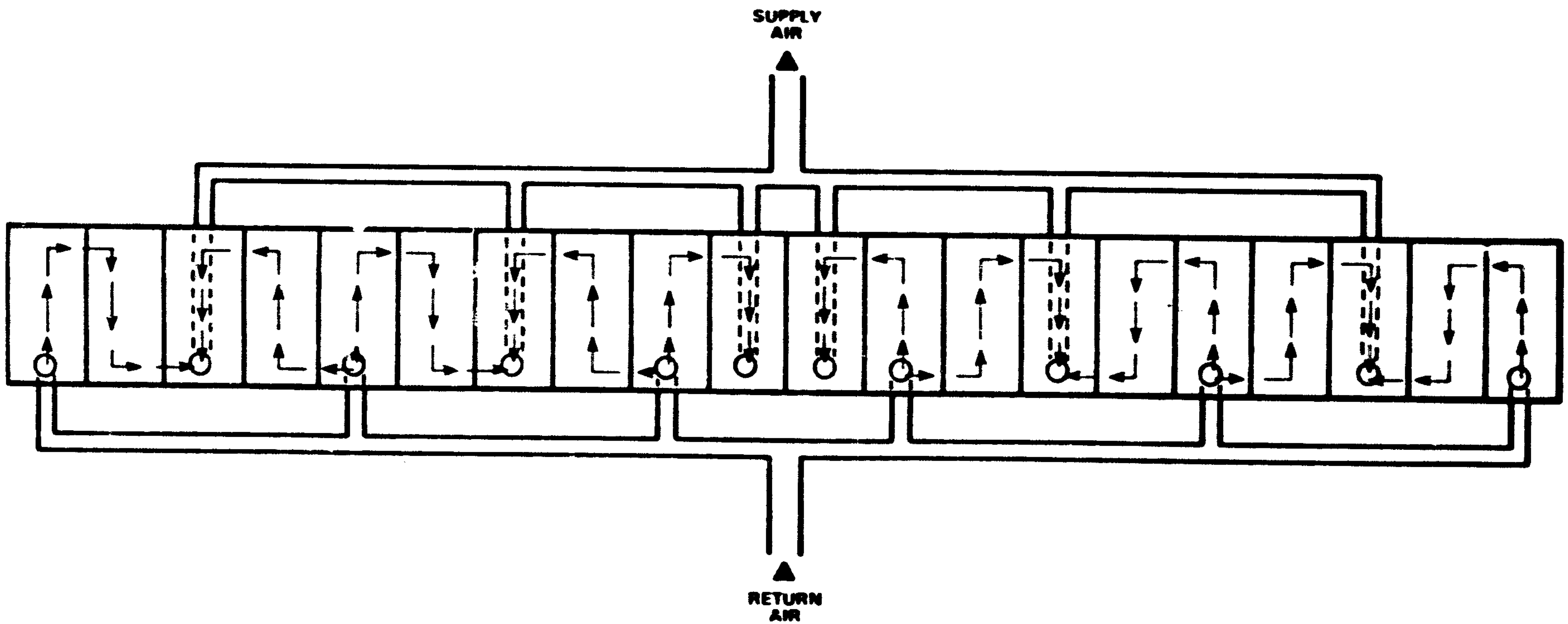


Figure VII Collector Arrangement for a Typical Row

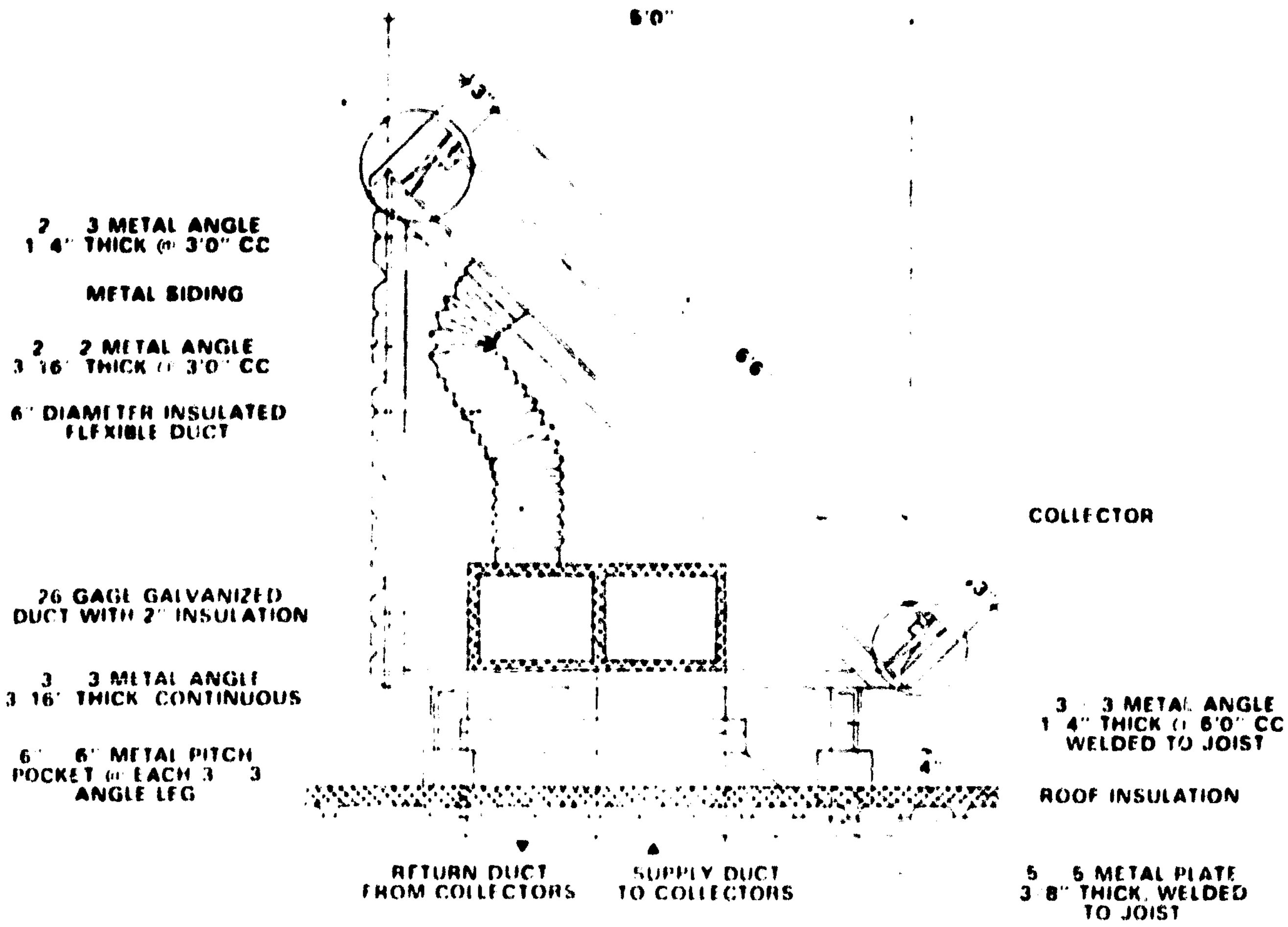


Figure VIII Cross Section of Collector Support

IX PERFORMANCE EVALUATION INSTRUMENTATION

A. The National Solar Data Network

The National Solar Data Network (see Figure IX) has been developed for the Department of Energy to process data collected from specific commercial demonstration sites which were selected for thermal performance evaluation. The data flow in the Network is shown in figure X. Products from the Network includes monthly and seasonal system-performance reports describing the thermal performance of the solar energy system and subsystems.

The performance evaluation instrumentation at each selected demonstration site is part of a comprehensive data collection system that allows for valid analyses of the solar system performance. Collected data are both applicable and practical in calculating thermal performance factors that describe the behavior of the solar system (see NBSIR 76-1137, National Bureau of Standards). Additional instrumentation may also be included as a result of site-specific requirements. Typically, the instrumentation includes sensors that monitor the following:

- Total insolation in the plane of the collector array
- Ambient temperature
- Collector subsystem flow rate and temperatures
- Storage inlet flow rate and temperatures
- Storage outlet flow rate and temperatures
- Storage temperature
- Storage-to-load subsystem flow rate and temperatures
- Auxiliary fuel flow rates

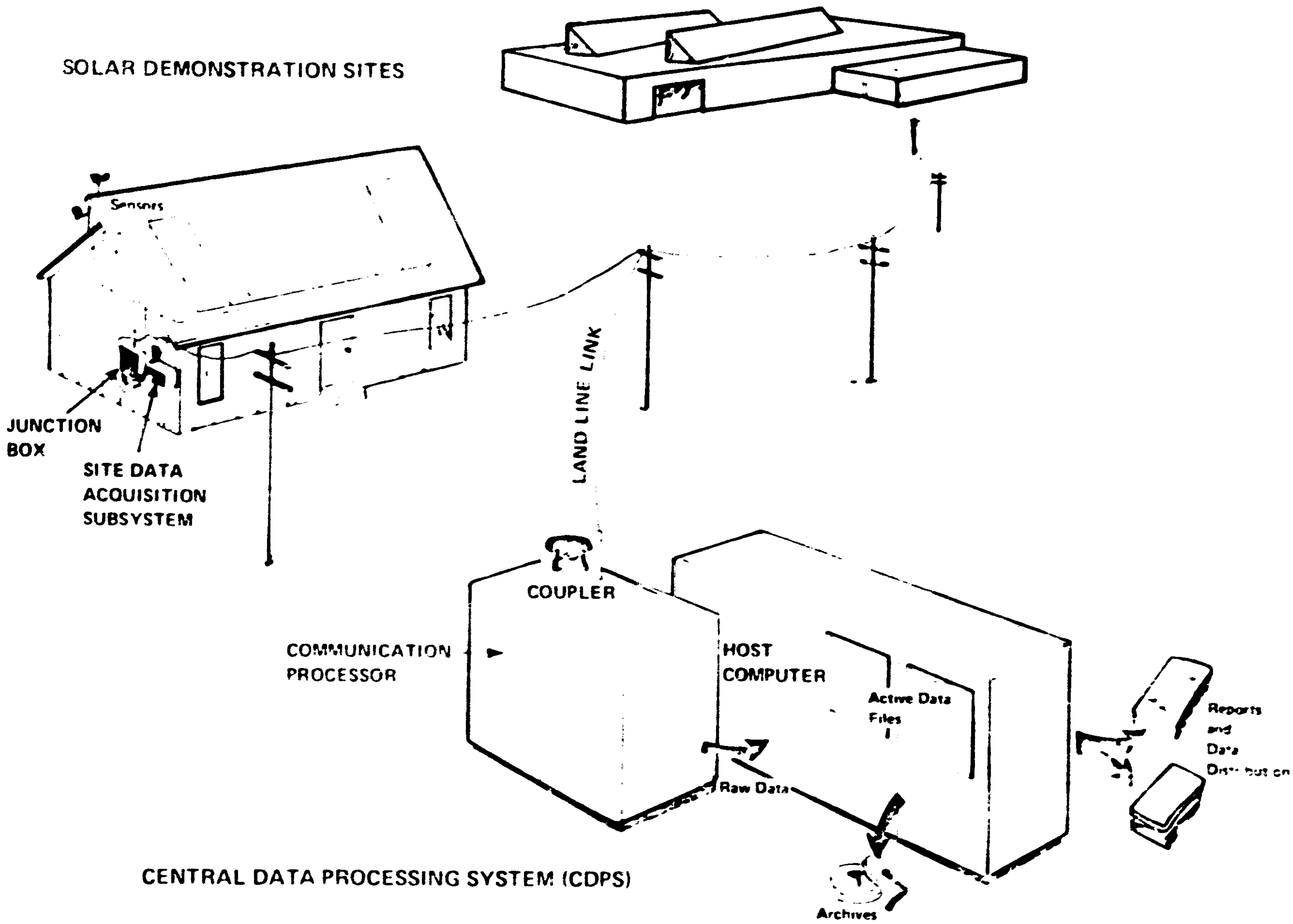


Figure IX The National Solar Data Network

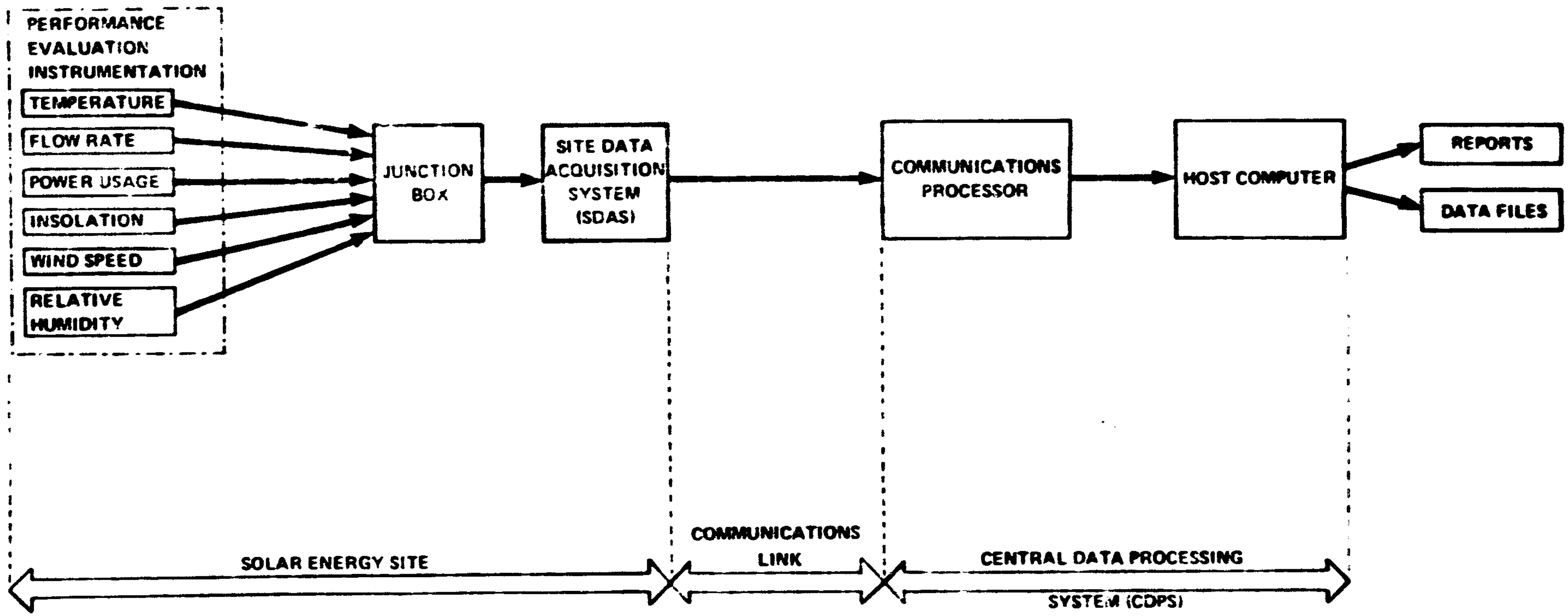


FIGURE X DATA FLOW PATH FOR THE NATIONAL SOLAR DATA NETWORK

Site data are recorded automatically at prescribed intervals by the Site Data Acquisition System (SDAS). The recorded data are transmitted daily to the Communications Processor in the Central Data Processing System (CDPS). The communications link between every SDAS and the CDPS consists of voice-grade telephone lines and telephone data couplers. A reading is transmitted from the SDAS internal timer with every data sample to ensure that the data are time-tagged correctly.

The Communications Processor scans the receiving data to identify any apparent transmission errors and verifies correct site contact by checking the address code transmitted by the SDAS. Data are stored temporarily in the Communications Processor and processed by the Host Computer. The processing includes measurement checking to ensure that the data are reasonable; that is, that they are not beyond the known instrument limits and they are not erratic. Data which appear questionable are discarded and are not used in the solar system performance analyses.

Appropriate equations were formulated and programmed to define desired performance factors for the solar energy systems at each selected demonstration site. A performance factor is a number that describes either the efficiency or the quantity of energy lost, gained, or converted by a solar energy system or by a component. All valid data are processed using these performance factor equations to generate hourly performance factors. Hourly performance factors are integrated into daily and monthly performance factors. These hourly, daily, and monthly performance factors are stored in data files in the CDPS. These data files also include measurement data, expressed in engineering units; numerical

and textual site identification; and specific site data used in generating the performance factors.

B. Onsite Instrumentation

The onsite instrumentation includes sensors to monitor the various parameters of the solar energy system, a junction box, and a Site Data Acquisition System that stores and transmits data to the Host Computer (see figures IX and X). Specific information for temperature, flow, power, and miscellaneous sensors is presented in tables 1 through 4, respectively. Sensor locations are shown in figure XI.

Table 1 Temperature Instrumentation for Ducat Investment

SENSOR	NAME	RANGE (°F)		MFGR	THERMOWELL PART NO	PROBE PART NO
		Min	Max			
T001	Outdoor Ambient Temperature	-20	120	Minco	IS4	S53P40Z36
T100	Collector Array Inlet Temperature (Unit 8)	30	160	Minco	F132	S53P85Z36
T150	Collector Array Outlet Temperature (8)	30	230	Minco	F132	S53P85Z36
T402	MD1 Inlet Temperature (8)	30	160	Minco	F132	S53P85Z36
T401	Auxiliary Heat Outlet Temperature (8)	30	[illegible]	Minco	F132	S53P85Z36
T600	Indoor Ambient Temperature (8)	30	[illegible]	Minco	IS4	S53P40Z36
T110	Collector Array Inlet Temperature (Unit 12)	30	160	Minco	F132	S53P85Z36
T160	Collector Array Outlet Temperature (12)	30	230	Minco	F132	S53P85Z36
T412	MD1 Inlet Temperature (12)	30	160	Minco	F132	S53P85Z36
T411	Auxiliary Heat Outlet Temperature (12)	30	230	Minco	F132	S53P85Z36
T610	Indoor Ambient Air Temperature (12)	30	160	Minco	IS4	S53P40Z36
T120	Collector Array Inlet Temperature (Unit 17)	30	160	Minco	F132	S53P85Z36
T170	Collector Array Outlet Temperature (17)	30	230	Minco	F132	S53P85Z36
T422	MD1 Inlet Temperature (17)	30	160	Minco	F132	S53P85Z36
T421	Auxiliary Heat Outlet Temperature (17)	30	230	Minco	F132	S53P85Z36
T620	Indoor Ambient Air Temperature (17)	30	160	Minco	IS4	S53P40Z36
T130	Collector Array Inlet Temperature (Unit 20)	30	160	Minco	F132	S53P85Z36
T180	Collector Array Outlet Temperature (20)	30	230	Minco	F132	S53P85Z36
T432	MD1 Inlet Temperature (20)	30	160	Minco	F132	S53P85Z36
T431	Auxiliary Heat Outlet Temperature (20)	30	230	Minco	F132	S53P85Z36
T630	Indoor Ambient Air Temperature (20)	30	160	Minco	IS4	S53P40Z36

Table 2 Flow Rate Instrumentation for Ducat Investment

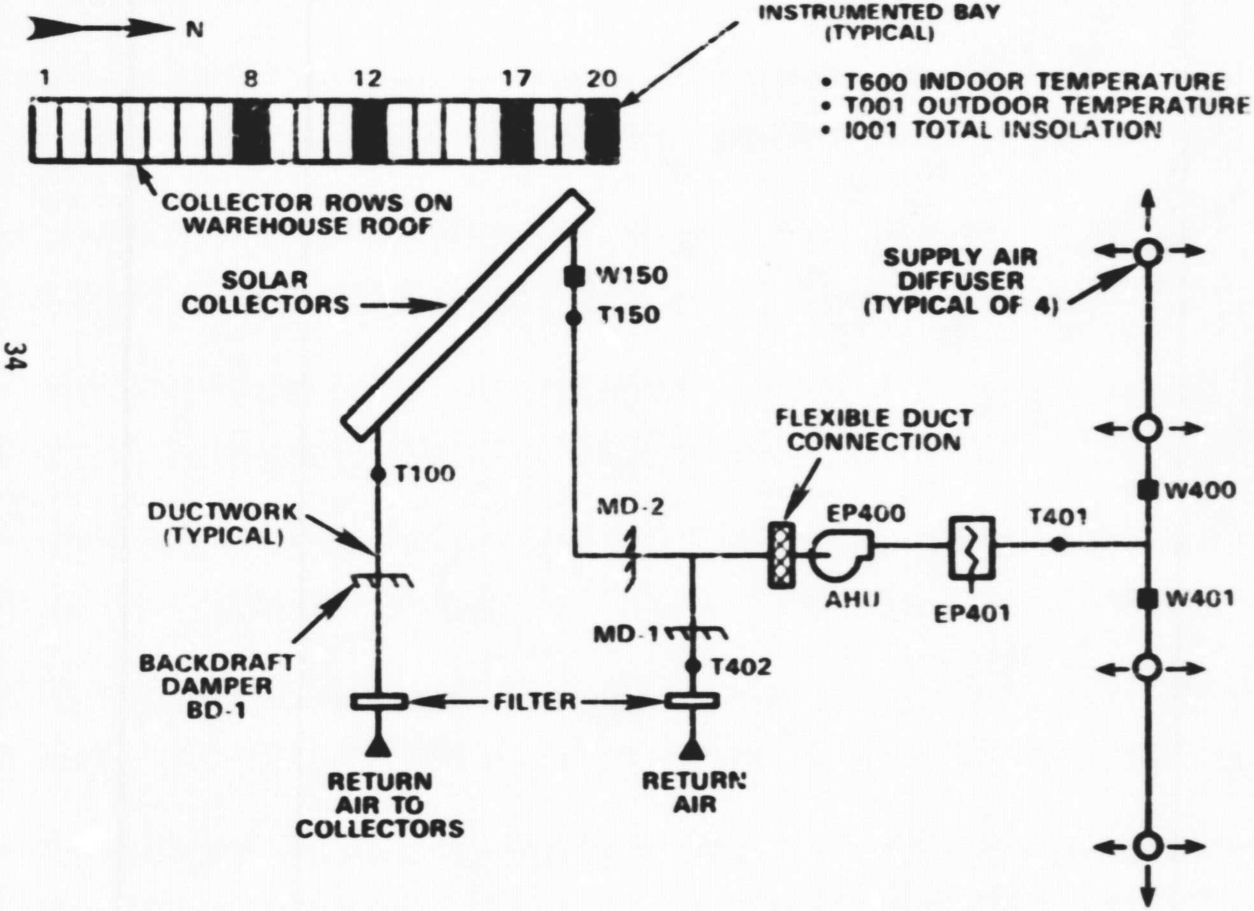
SENSOR	NAME	RANGE (FPM)		MFGR.	MODEL NO
		Min.	Max.		
W150	Solar Array Outlet Flow/Rate (Unit 8)	0	1250	Sierra	430-2
W400	½ System Air Flow (8)	0	1250	Sierra	430-2
W401	½ System Air Flow (8)	0	1250	Sierra	430-2
W160	Solar Array Outlet Flow Rate (Unit 12)	0	1250	Sierra	430-2
W410	½ System Air Flow (12)	0	1250	Sierra	430-2
W411	½ System Air Flow (12)	0	1250	Sierra	430-2
W170	Solar Array Order Flow Rate (Unit 17)	0	1250	Sierra	430-2
W420	½ System Air Flow (17)	0	1250	Sierra	430-2
W421	½ System Air Flow (17)	0	1250	Sierra	430-2
W180	Solar Array Outlet Flow Rate (Unit 20)	0	1250	Sierra	430-2
W430	½ System Air Flow (20)	0	1250	Sierra	430-2
W431	½ System Air Flow (20)	0	1250	Sierra	430-2

Table 3 Power Instrumentation for Ducat investment

SENSOR	NAME	PHASE	RANGE (kw)		MFGR.	MODEL NO.
			Min.	Max.		
EP400	Air Handling Unit Input Power (Unit 8)	1	0	1	Ohio Semitronics	PC5 2F
EP401	Auxiliary Heating Power (8)	3	0	20	Ohio Semitronics	PC5-54F
EP410	Air Handling Unit Input Power (Unit 12)	1	0	1	Ohio Semitronics	PC5-2F
EP411	Auxiliary Heating Power (12)	3	0	20	Ohio Semitronics	PC5-54F
EP420	Air Handling Unit Input Power (Unit 17)	1	0	1	Ohio Semitronics	PC5-2F
EP421	Auxiliary Heating Power (17)	3	0	20	Ohio Semitronics	PC5-54F
EP430	Air Handling Unit Input Power (Unit 20)	1	0	1	Ohio Semitronics	PC5-2F
EP431	Auxiliary Heating Power (20)	3	0	20	Ohio Semitronics	PC5-54F

Table 4 Miscellaneous Instrumentation for Ducat Investment

SENSOR	NAME	RANGE (Btu/ft^2-hr)		MFGR.	MODEL NO
		Min.	Max.		
1001	Total Solar Insolation	0	331.81	Eppley Labs	PSP



INSTRUMENTED BAYS				
BAY	8	12	17	20
	T100	T110	T120	T130
	T150	T160	T170	T180
	T400	T410	T420	T430
IBM	T401	T411	T421	T431
SENSOR	T402	T412	T422	T432
DESIG-	T600	T610	T620	T630
NATION	W400	W410	W420	W430
	W401	W411	W421	W431
	EP400	EP410	EP420	EP430
	EP401	EP411	EP421	EP431
			T001	
			I001	

Figure XI Collector-to-Load System

X ACCEPTANCE TESTS

DUCAT OFFICE & WAREHOUSE

SYSTEM 8 - Bay 8

SYSTEM TEST 1 - Visual System Installation Inspection

TEST OBJECTIVE:

A visual system inspection to verify that all system components are installed correctly, sized properly, and in their proper place within the system.

TEST PREREQUISITE:

All system components must conform to "as built" drawings and specifications.

Technician: Jack Searcy

Date: 5/23/79

Time: 8:30 a.m.

	System Component	Approved (✓)	Non Approved (✓)	Corrections made to meet test acceptance
1.	Solar collectors	(X)	( )	
2.	Collector manifold ductwork (rectangular)	(X)	( )	
3.	Collector manifold ductwork (round flexible)	(X)	( )	
4.	Return air filter	(X)	( )	
5.	Air handler	(X)	( )	
6.	Motor dampers	(X)	( )	
7.	Back draft dampers	(X)	( )	
8.	Controls	(X)	( )	
9.	Supply registers	(X)	( )	

SYSTEM TEST 2 - System Operation

TEST OBJECTIVE:

A manual inspection to verify that all fans, dampers, controls and air distribution systems are operating as specified.

TEST PREREQUISITE:

Components must operate as indicated by following operational mode sequence.

Technician: Jack Searcy

Date: 5/23/79

Time: 12:50

T2-A - Heating from Collector

Procedure: Set space thermostat to call for 1st stage heat. If collector heat is not available this mode can be simulated by disconnecting temperature sensor Tco or Tci lead at differential controller.

Operation:	(✓) If system operates as indicated
Fan - ON	(X)
Motor Damper 1 - CLOSE	(X)
Motor Damper 2 - OPEN	(X)
Back Draft Damper - OPEN	(X)
Resistance Heater - OFF	(X)

NOTE: IF SYSTEM DOES NOT OPERATE AS INDICATED, CORRECT AS NECESSARY AND INDICATE CORRECTION MADE.

No Corrections necessary

T2-B - Heating With Supplemental Heat Only

Procedure: Set space thermostat to call for 2nd stage heat. If collector heat is still available disconnect both Tco and Tci sensor leads from temperature differential controller to simulate the absence of heat in the collectors.

Operation:	(✓) If system operates as indicated
Fan - ON	(X)
Motor Damper 1 - OPEN	(X)
Motor Damper 2 - CLOSE	(X)
Back Draft Damper - CLOSE	(X)
Resistance Heater - ON	(X)

NOTE: IF SYSTEM DOES NOT OPERATE AS INDICATED, CORRECT AS NECESSARY AND INDICATE CORRECTION MADE.

No corrections necessary

T2-C - Heating With Collector Heat And Supplemental Heat

Procedure: Set space thermostat to call for 2nd stage heat. If collector heat is available the following operation should result.

Operation:	(✓) If system operates as indicated
Fan - ON	(X)
Motor Damper 1 - CLOSED	(X)
Motor Damper 2 - OPEN	(X)
Back Draft Damper - OPEN	(X)
Resistance Heater - ON	(X)

NOTE: IF SYSTEM DOES NOT OPERATE AS INDICATED, CORRECT AS NECESSARY AND INDICATE CORRECTION MADE.

No corrections necessary

SYSTEM TEST 3 - Temperature Test

TEST OBJECTIVE:

To demonstrate temperatures at various points in the system.

TEST PREREQUISITE:

For collected solar heat to be usable the temperature at the collector must be 38°F $\pm$ 5° above the ambient room temperature.

Test Procedure:

Measure the ambient room temperature. Given that the indoor thermostat is set on first stage heat the solar system will operate if the temperature of air in the collectors is 38°F $\pm$ 5°F greater than ambient. The solar system will shut off when the difference between collector temperature and ambient temperature is reduced to 25°F $\pm$ 5°F. To simulate a reduction in temperature differential the room ambient temperature sensor can be warmed artifically.

Technician: Jack Searcy

Date: 5/23/79

Time: 1:05

A. Collector temperature 193 °F
B. Indoor ambient temperature 68 °F

Temperature "B" 193 °F - Temperature "A" 68 °F =

125 °F Temperature Differential.

Outside ambient = 75°F

NOTE: If Temperature Differential is greater than 38°F $\pm$ 5°F the solar system should be operating. If Temperature Differential is less than 25°F $\pm$ 5°F the solar system should not be operating and the supplemental heat should be on.

NOTE: IF SYSTEM DOES NOT OPERATE AS INDICATED, CORRECT AS NECESSARY AND INDICATE CORRECTION MADE.

SYSTEM TEST 4 - Electrical Usage

TEST OBJECTIVE:

Measure amp load on blower motor.

TEST PREREQUISITE:

Test must indicate that amperage draw is within manufacturer's specification as listed below.

TEST PROCEDURE:

Component	Manufacture Spec. Fla	AMP Load
Fan	3.5	2.7

NOTE: IF MEASURED AMP LOAD IS GREATER THAN INDICATED ABOVE, CORRECT AS NECESSARY AND INDICATE CORRECTION MADE.

Technician: Jack Searcy

Date: 5/23/79

Time: 1:10

OFFICE TEST 5 - Collector Flow and Pressure Drop

TEST OBJECTIVE:

Measure collector flow rate in cubic feet per minute.

TEST PREREQUISITE:

System flow rate and pressure drop must conform as specified below.

TEST PROCEDURE:

Measure system velocity and pressure drop at cold air and hot air collector manifold duct using a air velometer.

Specified velocity	Measured velocity
700-800 FPM	757.2
Specified CFM	**Measured CFM**
780-1170 CFM	954
Specified Pressure Drop	**Measured Pressure Drop**
Approximately .23"	.21 iwg

NOTE: IF MEASUREMENTS DO NOT REFLECT THE ABOVE SPECIFICATIONS, BALANCE SYSTEM ACCORDINGLY.

Technician: Jack Searcy

Date: 5/23/79

Time: 1:15

DUCAT OFFICE & WAREHOUSE

SYSTEM 12 - Bay 12

SYSTEM TEST 1 - Visual System Installation Inspection

TEST OBJECTIVE:

A visual system inspection to verify that all system components are installed correctly, sized properly, and in their proper place within the system.

TEST PREREQUISITE:

All system components must conform to "as built" drawings and specifications.

Technician: Jack Searcy

Date: 5/23/79

Time: 8:45 a.m.

	System Component	Approved (✓)	Non Approved (✓)	Corrections made to meet test acceptance
1.	Solar collectors	(X)	( )	
2.	Collector manifold ductwork(rectangular)	(X)	( )	
3.	Collector manifold ductwork(round flexible)	(X)	( )	
4.	Return air filter	(X)	( )	
5.	Air handler	(X)	( )	
6.	Motor dampers	(X)	( )	
7.	Back draft dampers	(X)	( )	
8.	Controls	(X)	( )	
9.	Supply registers	(X)	( )	

SYSTEM TEST 2 - System Operation

TEST OBJECTIVE:

A manual inspection to verify that all fans, dampers, controls and air distribution systems are operating as specified.

TEST PREREQUISITE:

Components must operate as indicated by following operational mode sequence.

Technician: Jack Searcy

Date: 5/23/79

Time: 9:15 a.m.

T2-A - Heating from Collector

Procedure: Set space thermostat to call for 1st stage heat. If collector heat is not available this mode can be simulated by disconnecting temperature sensor Tco or Tci lead at differential controller.

Operation:	( ) If system operates as indicated
Fan - ON	(X)
Motor Damper 1 - CLOSE	(X)
Motor Damper 2 - OPEN	(X)
Back Draft Damper - OPEN	(X)
Resistance Heater - OFF	(X)

NOTE: IF SYSTEM DOES NOT OPERATE AS INDICATED, CORRECT AS NECESSARY AND INDICATE CORRECTION MADE.

No corrections necessary

T2-B - Heating With Supplemental Heat Only

Procedure: Set space thermostat to call for 2nd stage heat. If collector heat is still available disconnect both Tco and Tci sensor leads from temperature differential controller to simulate the absence of heat in the collectors.

Operation:	(✓)	If system operates as indicated
Fan - ON	(X)	
Motor Damper 1 - OPEN	(X)	
Motor Damper 2 - CLOSE	(X)	
Back Draft Damper - CLOSE	(X)	
Resistance Heater - ON	(X)	

NOTE: IF SYSTEM DOES NOT OPERATE AS INDICATED, CORRECT AS NECESSARY AND INDICATE CORRECTION MADE.

No corrections necessary

T2-C - Heating With Collector Heat And Supplemental Heat

Procedure: Set space thermostat to call for 2nd stage heat. If collector heat is available the following operation should result.

Operation:	(✓)	If system operates as indicated
Fan - ON	(X)	
Motor Damper 1 - CLOSED	(X)	
Motor Damper 2 - OPEN	(X)	
Back Draft Damper - OPEN	(X)	
Resistance Heater - ON	(X)	

NOTE: IF SYSTEM DOES NOT OPERATE AS INDICATED, CORRECT AS NECESSARY AND INDICATE CORRECTION MADE.

No corrections necessary

DUCAT OFFICE / WAREHOUSE

SYSTEM TEST 3 - Temperature Test

TEST OBJECTIVE:

To demonstrate temperatures at various points in the system.

TEST PREREQUISITE:

For collected solar heat to be usable the temperature at the collector must be 38°F± 5° above the ambient room temperature.

Test Procedure:

Measure the ambient room temperature. Given that the indoor thermostat is set on first stage heat the solar system will operate if the temperature of air in the collectors is 38°F± 5°F greater than ambient. The solar system will shut off when the difference between collector temperature and ambient temperature is reduced to 25°F ± 5°F. To simulate a reduction in temperature differential the room ambient temperature sensor can be warmed artifically.

Technician: Jack Searcy

Date: 5/23/79

Time: 10:30

A. Collector temperature 117 °F
B. Indoor ambient temperature 72 °F

Temperature "B" 117 °F - Temperature "A" 72 °F =

45 °F Temperature Differential.

Outside ambient = 68°F

NOTE: If Temperature Differential is greater than 38°F ± 5°F the solar system should be operating. If Temperature Differential is less than 25°F ± 5°F the solar system should not be operating and the supplemental heat should be on.

NOTE: IF SYSTEM DOES NOT OPERATE AS INDICATED, CORRECT AS NECESSARY AND INDICATE CORRECTION MADE.

SYSTEM TEST 4 - Electrical Usage

TEST OBJECTIVE:

Measure amp load on blower motor.

TEST PREREQUISITE:

Test must indicate that amperage draw is within manufacturer's specification as listed below.

TEST PROCEDURE:

Component	Manufacture Spec. Fla	AMP Load
Fan	3.5	2.9

NOTE: IF MEASURED AMP LOAD IS GREATER THAN INDICATED ABOVE, CORRECT AS NECESSARY AND INDICATE CORRECTION MADE.

Technician: Jack Searcy

Date: 5/23/79

Time: 9:45 a.m.

OFFICE TEST 5 - Collector Flow and Pressure Drop

TEST OBJECTIVE:

Measure collector flow rate in cubic feet per minute.

TEST PREREQUISITE:

System flow rate and pressure drop must conform as specified below.

TEST PROCEDURE:

Measure system velocity and pressure drop at cold air and hot air collector manifold duct using a air velometer.

Specified velocity	Measured velocity
700-800 FPM	788 FPM
Specified CFM	Measured CFM
780-1170 CFM	995 CFM
Specified Pressure Drop	Measured Pressure Drop
Approximately .23"	.23 iwg

NOTE: IF MEASUREMENTS DO NOT REFLECT THE ABOVE SPECIFICATIONS, BALANCE SYSTEM ACCORDINGLY.

Technician: Jack Searcy

Date: 5/23/79

Time: 10:00

DUCAT OFFICE & WAREHOUSE

SYSTEM 17 - Bay 17

SYSTEM TEST 1 - Visual System Installation Inspection

TEST OBJECTIVE:

A visual system inspection to verify that all system components are installed correctly, sized properly, and in their proper place within the system.

TEST PREREQUISITE:

All system components must conform to "as built" drawings and specifications.

Technician: Jack Searcy

Date: 5/23/79

Time: 8:55 a.m.

	System Component	Approved (✓)	Non Approved (✓)	Corrections made to meet test acceptance
1.	Solar collectors	(X)	( )	
2.	Collector manifold ductwork (rectangular)	(X)	( )	
3.	Collector manifold ductwork (round flexible)	(X)	( )	
4.	Return air filter	(X)	( )	
5.	Air handler	(X)	( )	
6.	Motor dampers	(X)	( )	
7.	Back draft dampers	(X)	( )	
8.	Controls	(X)	( )	
9.	Supply registers	(X)	( )	

SYSTEM TEST 2 - System Operation

TEST OBJECTIVE:

A manual inspection to verify that all fans, dampers, controls and air distribution systems are operating as specified.

TEST PREREQUISITE:

Components must operate as indicated by following operational mode sequence.

Technician: Jack Searcy

Date: 5/23/79

Time: 10:45 a.m.

T2-A - Heating from Collector

Procedure: Set space thermostat to call for 1st stage heat. If collector heat is not available this mode can be simulated by disconnecting temperature sensor Tco or Tci lead at differential controller.

Operation:	(✓) If system operates as indicated
Fan - ON	(X)
Motor Damper 1 - CLOSE	(X)
Motor Damper 2 - OPEN	(X)
Back Draft Damper - OPEN	(X)
Resistance Heater - OFF	(X)

NOTE: IF SYSTEM DOES NOT OPERATE AS INDICATED, CORRECT AS NECESSARY AND INDICATE CORRECTION MADE.

No corrections necessary

T2-B - Heating With Supplemental Heat Only

Procedure: Set space thermostat to call for 2nd stage heat. If collector heat is still available disconnect both Tco and Tci sensor leads from temperature differential controller to simulate the absence of heat in the collectors.

Operation: (✓) If system operates as indicated
Fan - ON (X)
Motor Damper 1 - OPEN (X)
Motor Damper 2 - CLOSE (X)
Back Draft Damper - CLOSE (X)
Resistance Heater - ON (X)

NOTE: IF SYSTEM DOES NOT OPERATE AS INDICATED, CORRECT AS NECESSARY AND INDICATE CORRECTION MADE.

No corrections necessary

T2-C - Heating With Collector Heat And Supplemental Heat

Procedure: Set space thermostat to call for 2nd stage heat. If collector heat is available the following operation should result.

Operation: (✓) If system operates as indicated
Fan - ON (X)
Motor Damper 1 - CLOSED (X)
Motor Damper 2 - OPEN (X)
Back Draft Damper - OPEN (X)
Resistance Heater - ON (X)

NOTE: IF SYSTEM DOES NOT OPERATE AS INDICATED, CORRECT AS NECESSARY AND INDICATE CORRECTION MADE.

No corrections necessary

SYSTEM TEST 3 - Temperature Test

TEST OBJECTIVE:

To demonstrate temperatures at various points in the system.

TEST PREREQUISITE:

For collected solar heat to be usable the temperature at the collector must be 38°F ± 5° above the ambient room temperature.

Test Procedure:

Measure the ambient room temperature. Given that the indoor thermostat is set on first stage heat the solar system will operate if the temperature of air in the collectors is 38°F ± 5°F greater than ambient. The solar system will shut off when the difference between collector temperature and ambient temperature is reduced to 25°F ± 5°F. To simulate a reduction in temperature differential the room ambient temperature sensor can be warmed artifically.

Technician: Jack Searcy

Date: 5/23/79

Time: 11:00 a.m.

A. Collector temperature 160 °F
B. Indoor ambient temperature 72 °F

Temperature "B" 160 °F - Temperature "A" 72 °F =

88 °F Temperature Differential.

Outside ambient = 71°F

NOTE: If Temperature Differential is greater than 38°F ± 5°F the solar system should be operating. If Temperature Differential is less than 25°F ± 5°F the solar system should not be operating and the supplemental heat should be on.

NOTE: IF SYSTEM DOES NOT OPERATE AS INDICATED, CORRECT AS NECESSARY AND INDICATE CORRECTION MADE.

SYSTEM TEST 4 - Electrical Usage

TEST OBJECTIVE:

Measure amp load on blower motor.

TEST PREREQUISITE:

Test must indicate that amperage draw is within manufacturer's specification as listed below.

TEST PROCEDURE:

Component	Manufacture Spec. Fla	AMP Load
Fan	3.5	2.8

NOTE: IF MEASURED AMP LOAD IS GREATER THAN INDICATED ABOVE, CORRECT AS NECESSARY AND INDICATE CORRECTION MADE.

Technician: Jack Searcy

Date: 5/23/79

Time: 11:05

OFFICE TEST 5 - Collector Flow and Pressure Drop

TEST OBJECTIVE:

Measure collector flow rate in cubic feet per minute.

TEST PREREQUISITE:

System flow rate and pressure drop must conform as specified below.

TEST PROCEDURE:

Measure system velocity and pressure drop at cold air and hot air collector manifold duct using a air velometer.

Specified velocity	Measured velocity
700-800 FPM	768.8
Specified CFM	**Measured CFM**
780-1170 CFM	971.7
Specified Pressure Drop	**Measured Pressure Drop**
Approximately .23"	.25 iwg

NOTE: IF MEASUREMENTS DO NOT REFLECT THE ABOVE SPECIFICATIONS, BALANCE SYSTEM ACCORDINGLY.

Technician: Jack Searcy

Date: 5/23/79

Time: 11:10 a.m.

SYSTEM 20 - Bay 20

SYSTEM TEST 1 - Visual System Installation Inspection

TEST OBJECTIVE:

A visual system inspection to verify that all system components are installed correctly, sized properly, and in their proper place within the system.

TEST PREREQUISITE:

All system components must conform to "as built" drawings and specifications.

Technician: Jack Searcy

Date. 5/23/79

Time 9:05 a.m.

	System Component	Approved (✓)	Non Approved (✓)	Corrections made to meet test acceptance
1.	Solar collectors	(X)	( )	
2.	Collector manifold ductwork(rectangular)	(X)	( )	
3.	Collector manifold ductwork(round flexible)	(X)	( )	
4.	Return air filter	( )	(X)	Dirty/replace
5.	Air handler	(X)	( )	
6.	Motor dampers	(X)	( )	
7.	Back draft dampers	(X)	( )	
8.	Controls	(X)	( )	
9.	Supply registers	(X)	( )	

SYSTEM TEST 2 - System Operation

TEST OBJECTIVE:

A manual inspection to verify that all fans, dampers, controls and air distribution systems are operating as specified.

TEST PREREQUISITE:

Components must operate as indicated by following operational mode sequence.

Technician: Jack Searcy

Date: 5/23/79

Time: 11:40 a.m.

T2-A - Heating from Collector

Procedure: Set space thermostat to call for 1st stage heat. If collector heat is not available this mode can be simulated by disconnecting temperature sensor Tco or Tci lead at differential controller.

Operation:	(✓) If system operates as indicated
Fan - ON	(X)
Motor Damper 1 - CLOSE	(X)
Motor Damper 2 - OPEN	(X)
Back Draft Damper - OPEN	(X)
Resistance Heater - OFF	(X)

NOTE: IF SYSTEM DOES NOT OPERATE AS INDICATED, CORRECT AS NECESSARY AND INDICATE CORRECTION MADE.

No corrections necessary

T2-B - Heating With Supplemental Heat Only

Procedure: Set space thermostat to call for 2nd stage heat. If collector heat is still available disconnect both Tco and Tci sensor leads from temperature differential controller to simulate the absence of heat in the collectors.

Operation:	(✓) If system operates as indicated
Fan - ON	(X)
Motor Damper 1 - OPEN	(X)
Motor Damper 2 - CLOSE	(X)
Back Draft Damper - CLOSE	(X)
Resistance Heater - ON	(NO)

NOTE: IF SYSTEM DOES NOT OPERATE AS INDICATED, CORRECT AS NECESSARY AND INDICATE CORRECTION MADE.

Spade clip on low voltage had come loose - Reconnect and check out

T2-C - Heating With Collector Heat And Supplemental Heat

Procedure: Set space thermostat to call for 2nd stage heat. If collector heat is available the following operation should result.

Operation:	(✓) If system operates as indicated
Fan - ON	(X)
Motor Damper 1 - CLOSED	(X)
Motor Damper 2 - OPEN	(X)
Back Draft Damper - OPEN	(X)
Resistance Heater - ON	(X)

NOTE: IF SYSTEM DOES NOT OPERATE AS INDICATED, CORRECT AS NECESSARY AND INDICATE CORRECTION MADE.

No corrections necessary

SYSTEM TEST 3 - Temperature Test

TEST OBJECTIVE:

To demonstrate temperatures at various points in the system.

TEST PREREQUISITE:

For collected solar heat to be usable the temperature at the collector must be 38°F$\pm$ 5° above the ambient room temperature.

Test Procedure:

Measure the ambient room temperature. Given that the indoor thermostat is set on first stage heat the solar system will operate if the temperature of air in the collectors is 38°F$\pm$ 5°F greater than ambient. The solar system will shut off when the difference between collector temperature and ambient temperature is reduced to 25°F $\pm$ 5°F. To simulate a reduction in temperature differential the room ambient temperature sensor can be warmed artifically.

Technician: Jack Searcy

Date: 5/23/79

Time: 12:10

A. Collector temperature 171 °F
B. Indoor ambient temperature 69 °F

Temperature "B" 171 °F - Temperature "A" 69 °F =

102 °F Temperature Differential.

Outside ambient = 73°F

NOTE: If Temperature Differential is greater than 38°F $\pm$ 5°F the solar system should be operating.
If Temperature Differential is less than 25°F $\pm$ 5°F the solar system should not be operating and the supplemental heat should be on.

NOTE: IF SYSTEM DOES NOT OPERATE AS INDICATED, CORRECT AS NECESSARY AND INDICATE CORRECTION MADE.

SYSTEM TEST 4 - Electrical Usage

TEST OBJECTIVE:

Measure amp load on blower motor.

TEST PREREQUISITE:

Test must indicate that amperage draw is within manufacturer's specification as listed below.

TEST PROCEDURE:

Component	Manufacture Spec. Fla	AMP Load
Fan	3.5	2.9

NOTE: IF MEASURED AMP LOAD IS GREATER THAN INDICATED ABOVE, CORRECT AS NECESSARY AND INDICATE CORRECTION MADE.

Technician: Jack Searcy

Date: 5/23/79

Time: 12:15

OFFICE TEST 5 - Collector Flow and Pressure Drop

TEST OBJECTIVE:

Measure collector flow rate in cubic feet per minute.

TEST PREREQUISITE:

System flow rate and pressure drop must conform as specified below.

TEST PROCEDURE:

Measure system velocity and pressure drop at cold air and hot air collector manifold duct using a air velometer.

Specified velocity	Measured velocity
700-800 FPM	776.6
Specified CFM	Measured CFM
780-1170 CFM	978.5
Specified Pressure Drop	Measured Pressure Drop
Approximately .23"	2.0 iwg

NOTE: IF MEASUREMENTS DO NOT REFLECT THE ABOVE SPECIFICATIONS, BALANCE SYSTEM ACCORDINGLY.

Technician: Jack Searcy

Date: 5/23/79

Time: 12:20 a.m.

XI PREDICTED SYSTEM PERFORMANCE DATA

XI Predicted System Performance Data

* *

* * * * * SOLARON CORPORATION * * * * * *

* *

PROJECT..................... DUCAT WHS.

APPLICATION.................

LOCATION.................... COLUMBIA MO

LATITUDE.................... 39.0

SPECIFIED COLLECTOR AREA.... 7800. FT2

CODE	VARIABLE DESCRIPTION	VALUE	UNITS
1	SPACE & DHW HTG=1,DOM.WAT.HTG.ONLY=2..........	1.00	
2	COLLECTOR AREA................................	7800.00	FT2
3	FRPRIME-TAU ALPHA PRODUCT(NORMAL INCIDENCE)..	0.52	
4	FRPRIME-UL PRODUCT............................	0.63	BTU/H-F-F.
5	NUMBER OF TRANSPARENT COVERS..................	2.00	
6	COLLECTOR SLOPE...............................	45.00	DEGREES
7	AZIMUTH ANGLE (E.G. SOUTH=0, WEST=90)........	3.00	DEGREES
8	STORAGE CAPACITY..............................	7.50	BTU/F-FT2
9	BUILDING DESIGN HEAT LOSS..(*)................	0.00	BTU/HR
10	LOCATION DESIGN TEMPERATURE DIFFERENCE.......	52.00	F
11	CONSTANT DAILY BLDG HEAT GENERATION..........	0.00	BTU/DAY
12	HOT WATER USAGE...............................	0.00	GAL/DAY
13	WATER SET TEMPERATURE.........................	140.00	F
14	WATER MAIN TEMPERATURE........................	60.00	F
15	CITY CALL NUMBER..............................	23.00	
16	THERMAL PRINT OUT BY MONTH=1, BY YEAR=2......	1.00	
17	ECONOMIC ANALYSIS ? YES=1, NO=2.............	2.00	

TYPE IN CODE NUMBER AND NEW VALUE

(*) MONTHLY LOADS WERE USED

JAN	[illegible].000
FEB	[illegible].000
MAR	4[illegible].000
APR	1[illegible].000
MAY	460000.000
JUN	0.000
JUL	0.000
AUG	0.000
SEP	170000.000
OCT	930000.000
NOV	[illegible]790000.000
DEC	6240000.000

MONTHLY LOADS

$\frac{\text{BTU}}{\text{DAY}}$ AVERAGE

*** * * * THERMAL ANALYSIS * * * ***

TIME	PERCENT SOLAR	INCIDENT SOLAR (MILL) (BTU)	HEATING LOAD (MILL) (BTU)	WATER LOAD (MILL) (BTU)	DEGREE DAYS (F-DAY)	AMBIENT TEMP (F)
JAN	32.6	280.9	243.35	0.00	1076.	30.
FEB	49.2	296.0	174.72	0.00	874.	32.
MAR	87.1	370.2	106.02	0.00	716.	43.
APR	100.0	369.7	38.70	0.00	324.	54.
MAY	100.0	407.2	14.26	0.00	121.	64.
JUN	0.0	397.0	0.00	0.00	12.	73.
JUL	0.0	423.8	0.00	0.00	0.	77.
AUG	0.0	438.6	0.00	0.00	0.	75.
SEP	100.0	440.5	5.10	0.00	54.	68.
OCT	100.0	412.6	28.83	0.00	251.	57.
NOV	91.3	332.5	83.70	0.00	651.	43.
DEC	40.6	282.6	193.44	0.00	967.	32.
YR	56.2	4451.79	888.12	0.00	5046.	

ORIGINAL PAGE IS
OF POOR QUALITY

XII PROBLEMS ENCOUNTERED & RESOLUTIONS

XII PROBLEMS ENCOUNTERED & RESOLUTIONS

One problem which has re-occurred is damper air leakage through the motorized damper, located in the warm air supply duct from the collectors. This leakage occurs when there is a demand in the space for heat and the auxiliary electric heat source is called upon due to the absence of available solar heat. A single blower is used for solar heat and auxiliary heat. When the auxiliary heater is called for (usually at night) the blower comes on and draws a small portion of cold air through the leaking solar damper.

To correct this problem two options are available. First, replace this one damper with an even tighter fitting damper. Or second, separate the solar system from the auxiliary system. A second blower would need to be added to either the solar or auxiliary system in this case.

XIII LESSONS LEARNED AND RECOMMENDATIONS

XIII LESSONS LEARNED AND RECOMMENDATIONS

The overall system design is relatively simple and would be difficult to improve upon without complicating the design to any degree. With few exceptions the systems components have stood up well. Damper leakage is a recurrent problem for many air-type solar heating systems. It would be our recommendation that the very best tight seal damper available be used and as few dampers be used in the system as possible.

There have been no problems with system components (collectors or support framing) above the roof. However, we would suggest that as few roof penetrations as possible be made through the roof membrane.

Since space heating within a warehouse is the only purpose of this system it would be our recommendation that any elaborate distribution ductwork be eliminiated from the design.

XIV STATEMENTS OF CONFIRMATION

XIV STATEMENTS OF CONFIRMATION

This statement is to confirm the DuCat Investment Solar System installed on the building located at Interstate 635 and Shawnee Drive, Kansas City, Kansas:

A. Was installed per as built drawings

B. Met the Acceptance Test Plan provisions

C. Met the Interim Performance Criteria requirements

Signed

Timothy D. Duval

Timothy D. Duval
DuCat Investment Company

XV APPENDIX

XV. APPENDIX

A. Glossary

ABSORBER PLATE - The surface in a flat-plate collector that absorbs incident solar radiation and transfers the absorbed energy to a heat transfer fluid.

ABSORPTANCE - The ratio of absorbed radiation by a surface to the total incident radiation on that surface.

ABSORPTION SUBSYSTEM - The mechanical equipment that conditions indoor air by an absorption process.

ACTIVE SOLAR SYSTEM - An integrated solar energy system, consisting of collector, storage, solar energy-to-load subsystems, that can condition indoor air or preheat domestic hot water in a controlled manner.

AIR-BASED SOLAR COLLECTOR SYSTEM - A solar energy system in which air is the heat transfer fluid.

AIR CONDITIONING - The process of treating indoor air by controlling the temperature, humidity, and distribution to specified comfort settings as set by the occupants in the conditioned space.

AMBIENT AIR - A term for outdoor air, which may be brought into a building to be conditioned or circulated.

ANTIFREEZE FREEZE PROTECTION SYSTEM - A freeze protection system that uses a solution of water and glycol. This solution depresses its freezing point sufficiently to prevent possible water freeze in solar collectors and exterior piping.

AUXILIARY ENERGY SUBSYSTEM - The equipment which uses conventional energy sources to supplement the output provided by a solar energy system and to provide a full backup system when the solar system is inoperable.

BACKFLOW - The unintentional reversal of flow in a potable water distribution system by foreign or toxic substances that may contaminate the potable water.

BACKFLOW PREVENTER - A device or means to stop backflow.

BEAM RADIATION - Solar radiation which is not scattered and may be concentrated.

BRITISH THERMAL UNIT (Btu) - A unit of energy that is required to heat one pound of water from 59° F to 60° F.

BUILDING ENVELOPE - The exterior surface of a building that encloses the conditioned space.

CLIMATE - The prevailing or average weather conditions of a specific geographic region as described by temperature and other meteorological data.

COLLECTOR MANIFOLD - The piping that connects the absorber tubes in a collector plate.

COLLECTOR PLATE - A term used for an absorber plate.

COLLECTOR SUBSYSTEM - The assembly that absorbs incident solar radiation and transfers the absorbed thermal energy to a heat transfer fluid.

COMBINED COLLECTORS - An assembly that both collects incident solar radiation and stores the thermal energy in the same unit.

CONCENTRATING SOLAR COLLECTOR - A solar collector which focuses beam radiation onto an absorber to obtain higher energy fluxes than can normally be achieved by flat-plate solar collectors.

CONCENTRATOR - A reflective surface or refracting lens used in directing insolation onto an absorber.

CONDITIONED SPACE - The space in a building that has the air conditioned for heating and cooling.

CONTROL SUBSYSTEM - The assembly of electric, pneumatic, and hydraulic actuated sensing devices used in regulating the solar energy system and the auxiliary energy subsystem.

COOLING TOWER - A heat exchanger that transfers waste heat from an absorption cooling system to ambient air.

DIFFUSE RADIATION - Solar radiation which is scattered by air molecules, dust, or water droplets and cannot be focused.

DRAIN-DOWN FREEZE PROTECTION SYSTEM - A freeze protection system that prevents potential water freeze problems by automatically opening a valve to drain the solar collectors and exterior piping. Air is used for some systems, nitrogen for others.

DUCT HEATING COIL - A liquid-to-air heat exchanger in the duct distribution system used to heat air by passing a hot fluid into a coil in the airstream.

EMITTANCE - The ratio of energy radiated by a body to the energy radiated by a blackbody at the same temperature.

EQUIVALENT FULL LOAD COOLING HOURS - The seasonal cooling load for a building described as the total number of hours that the air conditioning system will operate under full load conditions to meet the required cooling load.

EXPANSION TANK - A tank which will permit water to expand whenever it is heated to prevent excessive pressures on the other system components.

FIXED COLLECTOR - A solar collector permanently oriented toward the sun which cannot track the sun nor be adjusted for seasonal variations.

FLAT-PLATE COLLECTOR - A basic heat collection device used in solar heating systems, which consists of an absorber plate, with insulated bottom and sides, and is covered by one or more transparent covers. There are no concentrators or focusing aids in a flat-plate collector.

FOCUSING COLLECTOR - A solar collector which uses a parabolic mirror, Fresnel lens or other type of focusing device to concentrate solar radiation onto an absorber.

FRESNEL COLLECTOR - A concentrating solar collector which uses a Fresnel lens to focus beam radiation onto an absorber.

GLAZING - The transparent cover(s) on a solar collector used to reduce the energy losses from the top of the collector.

HEAT TRANSFER FLUID - The fluid that transfers solar energy from the solar collector to the storage subsystem or to the load.

INCIDENCE ANGLE - The angle at which the insolation strikes a surface and the normal for that surface.

INSOLATION - The total amount of solar radiation on a surface in a given unit of time.

LAMINATED GLASS - A glazing consisting of multiple glass sheets bonded together by intervening layer or layers of plastic.

LANGLEY - The standard unit of insolation defined as 1 langley = 1 cal/cm^2 (1 langley = 3.69 Btu/ft^2).

LIQUID-BASED SOLAR COLLECTOR SYSTEM - A solar energy system in which either water or an antifreeze solution is the heat transfer fluid.

LOAD - The total space conditioning or domestic water heating requirements that are supplied by both the solar energy system and the auxiliary energy subsystem.

NOCTURNAL RADIATION - The loss of thermal energy by the solar collectors to the sky at night.

NO-FLOW CONDITION - The condition obtained when the heat transfer fluid is not flowing through the collector array due to shutdown or malfunction.

OPAQUE - A surface that is not transparent, thus solar radiation is either reflected or absorbed.

OUTGASSING - The emission of gases by materials and components, usually during exposure to elevated temperature or reduced pressure.

PACKAGE AIR-CONDITIONING UNIT - A factory-made assembly consisting of an indoor coil, a compressor, an outdoor coil, and other components needed for space cooling operations. Unit may also include additional components to heat the conditioned space.

PARABOLIC FOCUSING COLLECTOR - A concentrating collector which focuses beam radiation by a parabolic reflector.

PASSIVE SOLAR SYSTEM - An integrated solar energy system that can provide for space heating needs without use of an energy source other than the sun.

PEBBLE BED - A storage tank using uniform-sized pebbles to store solar energy in air-based solar collector systems.

REFLECTANCE - The ratio of radiation reflected by a surface to the total incident radiation on the surface.

REFLECTED RADIATION - Insolation which is reflected from a surface, such as the ground, and is incident on the solar collector.

SELECTIVE SURFACE - A surface which has a high absorptance for solar radiation and a low emittance for thermal radiation.

SOLAR CONDITIONED SPACE - The area in a building that depends on solar energy to provide a fraction of its heating and cooling needs.

SOLAR HEATING SYSTEM - An integrated assembly of collector, storage, solar energy-to-load, and control subsystems required to convert solar energy into thermal energy for space heating requirements--also includes an auxiliary backup system.

SOLAR RETROFIT - The addition of a solar energy system to an existing structure.

STORAGE SUBSYSTEM - The components used to store solar energy for use in heating or cooling air, or heating water during period of low insolation.

STRATIFICATION - The horizontal layering by a fluid due to temperature differentials, commonly noticed in storage tanks filled with water.

THERMOSTAT - A temperature dependent sensor which controls either the heating and cooling systems for space conditioning or the hot water heater.

TON OF REFRIGERATION - A unit of refrigeration equivalent to 12,000 Btu/hr.

TRACKING COLLECTOR - A solar energy collector that constantly moves to follow the path of the sun.

VAPOR BARRIER - A material which is used to reduce the transmission of water vapor.

ZONE - Portions of a conditioned space which use a common control because of their similar heating and cooling requirements.

B. Legend for Solar System Schematics

VALVES

- GATE VALVE
- CHECK VALVE
- BALANCING VALVE
- GLOBE VALVE
- BALL VALVE
- PLUG VALVE
- BACKFLOW PREVENTER
- VACUUM BREAKER
- RELIEF OR SAFETY
- PRESSURE REDUCING
- ANGLE GATE VALVE
- ANGLE GLOBE VALVE
- CONTROL VALVE, 2 WAY
- CONTROL VALVE, 3 WAY
- BUTTERFLY VALVE
- 4 WAY VALVE

FITTINGS

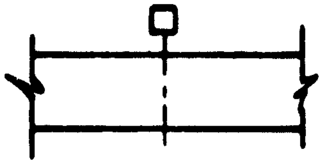
- DIRECTION OF FLOW
- CAP
- REDUCER, CONCENTRIC
- REDUCER, ECCENTRIC
- TEE
- UNION
- FLANGED CONNECTION
- CONNECTION, BOTTOM
- CONNECTION, TOP
- ELBOW, TURNED UP
- ELBOW, TURNED DOWN
- TEE, OUTLET UP
- TEE, OUTLET DOWN

PIPING SPECIALITIES

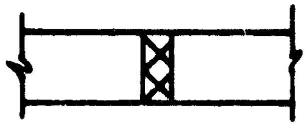
- AUTOMATIC AIR VENT
- MANUAL AIR VENT
- ALIGNMENT GUIDE
- ANCHOR
- BALL JOINT
- EJ — EXPANSION JOINT
- EXPANSION LOOP
- FLEXIBLE CONNECTION
- FLOWMETER FITTING
- FS — FLOW SWITCH
- PS — PRESSURE SWITCH
- PRESSURE GAUGE
- PUMP
- PIPE SLOPE
- STRAINER
- STRAINER, W/BLOW OFF
- TRAP
- C — CONTROL SENSOR
- INSTRUMENTATION SENSOR
- THERMOMETER
- THERMOMETER WELL ONLY
- CW — COLD WATER SUPPLY

AS	AIR SEPARATOR
EXP TK	EXPANSION TANK
WS	WATER SOFTENER
HED	HOSE END DRAIN

C. Duct Systems



MOTOR OPERATED DAMPER



FLEXIBLE CONNECTION

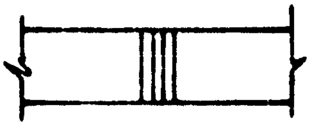
SUPPLY (UP)

SUPPLY (DOWN)

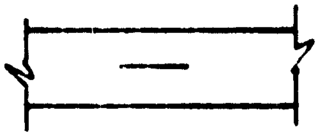
RETURN (UP)

RETURN (DOWN)

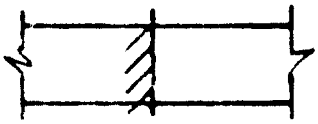
THERMOSTAT



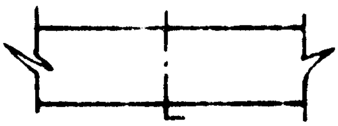
DUCT HEATING COIL



DIRECTION OF FLOW
DUCT SIZE, FIRST FIGURE IS SIDE SHOWN



BACK DRAFT DAMPER



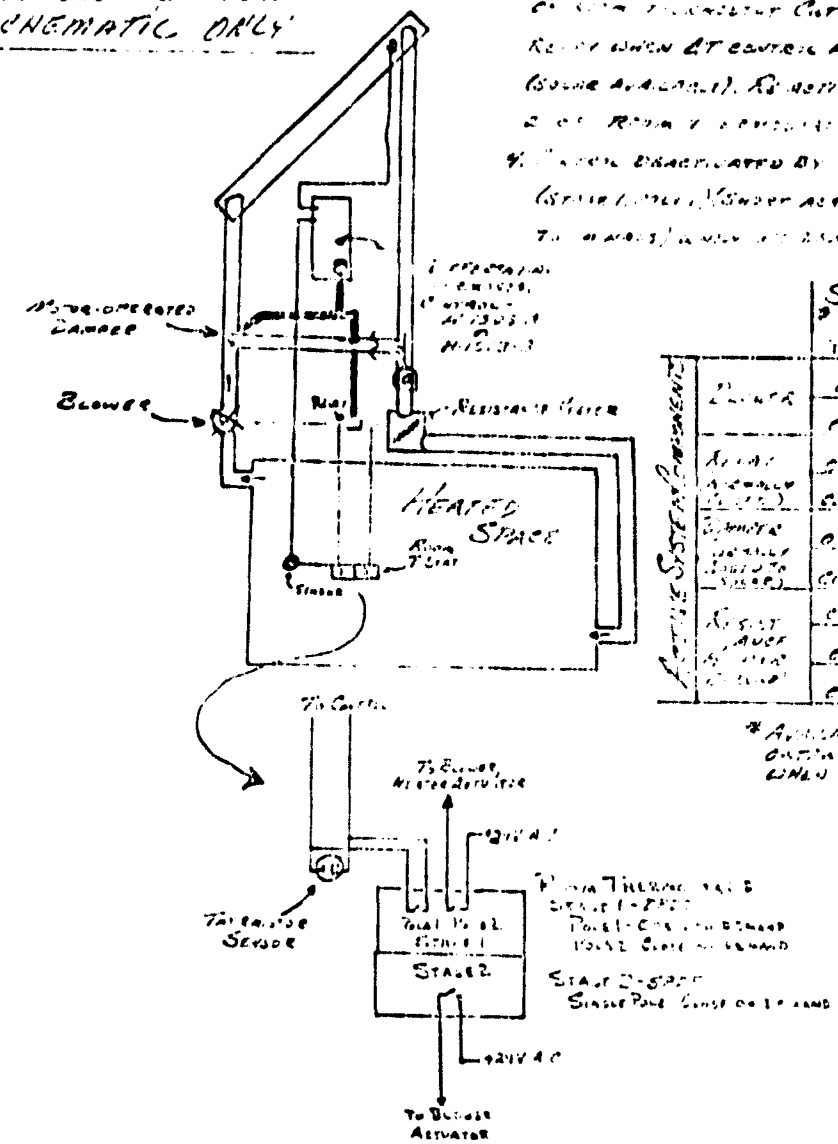
MANUAL VOLUME DAMPER

SUPPLY OUTLET

EXHAUST OR RETURN INLET

FAN

TYPICAL SYSTEM SCHEMATIC ONLY



1. BLOWER OPERATED BY DEMAND (STAGE 1) OF ROOM THERMOSTAT.

2. M.O. DAMPER OPERATED BY DIFFERENTIAL THERMOSTAT (DIVERTS AIRFLOW THRU COLLECTORS).

3. RESISTANCE HEATER OPERATED BY STAGE 1 OF ROOM THERMOSTAT CUT OUT BY MEANS OF RELAY WHEN ΔT CONTROL APPLIES POWER (SOLAR AVAILABLE). RE-ACTIVATED BY STAGE 2 OF ROOM THERMOSTAT.

4. [illegible] ACTIVATED BY ROOM THERMOSTAT [illegible] [illegible] [illegible] RAISE [illegible].

Active System Component	Solar Energy Available?* Yes	No	Demand from Room Thermostat?
Blower	ON	ON	Yes
	OFF	OFF	No
[illegible] Damper ([illegible])	Open	Closed	Yes
	Closed	Closed	No
[illegible]	Open	Closed	Yes
	Closed	Closed	No
Resistance Heater ([illegible])	OFF	ON	Yes Stage 1
	ON	ON	Yes Stage 2
	OFF	OFF	No

* AVAILABILITY OF SOLAR ENERGY IMPLIES OUTPUT FROM DIFFERENTIAL THERMOSTAT WHEN ROOM T-STAT INDICATES HEAT DEMAND.

117 V.A.C. CONTROL CURRENT
V.D.C. SENSOR LEAD
24 V.A.C. T-STAT CONTROL SIGNAL

12/15/77 J.B.C.
[illegible] INDUSTRIES, INC.
WEST PALM BEACH, FLORIDA

ORIGINAL PAGE IS
OF POOR QUALITY

XVI OPERATION AND MAINTENANCE MANUALS

XVI OPERATION AND MAINTENANCE MANUALS

System 8 through 20 (Bays 8 through 20)

Solar air heating system with electric furnance back up.

System Description:

The Du-Cat building is divided into 20 bays or sections. Each section (which space is devoted to open warehouse) has its own solar heating system which is backed up by an electric furnance. Each system has an array of 20 solar collectors located on the roof. The collector array is connected to a fan and electric furnance below the roof by ductwork. The ducted supply, fan and electric heater can be observed from the warehouse floor just below the steel ceiling joists.

System Operation:

The solar system is controlled by a two stage space heating thermostat located on the rear steel column approximately 5 feet above the floor. This thermostat controls two motorized dampers, the fan section, and the electric heater. The two motorized dampers are located in the hot air duct before it enters the fan section. Solar heat is governed by a temperature differential sensing device which is attached to the fan section.

The solar system operates as follows:

1. When the space heating thermostat calls for heat on stage 1, and there is sufficient heat in the collectors, (approximately 33°F above the indoor temperature) the fan will come on, the motorized dampers will shift into the solar flow position and inside air will be drawn through the collectors and delivered back to the warehouse space via the ductwork and registers.

2. Should the collectors be without sufficient heat (less than 33^{o}F) and the thermostat is still calling for heat, the motorized dampers will shift into the conventional heating position which bypasses the solar collectors completely. The fan will remain on and the electric furnance elements will turn on - supplying heat to the warehouse via the ductwork and registers.
3. Should there be sufficient heat in the collectors yet not enough to satisfy the demands of the space thermostat the motorized dampers will remain in the solar flow position and the electric furnance will remain on in order to satisfy the space heating requirements.

System Maintenance:

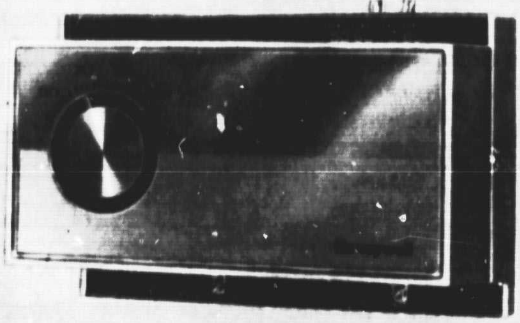
The motorized dampers should be checked before system start up in the fall. Occasional adjustments may be necessary to assure that the dampers are closing tightly. The fan is permanently lubricated at the factory and should not require future lubrication. The electric strip heaters should not require adjustment. However, if failure occurs, a qualified serviceman should make the repairs. The solar collectors do not require maintenance. The collectors should be visually checked occasionally for glass breakage, etc. There are two furnance filters located in the ductwork below the roof. These filters are apparent to the observer and should be changed at least once a month during the heating season.

Honeywell

MULTISTAGE THERMOSTAT AND SUBBASE

THESE THERMOSTATS AND SUBBASES PROVIDE LOW VOLTAGE CONTROL OF MULTISTAGE HEATING AND COOLING SYSTEMS INCLUDING HEAT PUMP SYSTEMS.

- T872 Thermostat requires a Q672 Subbase.
- Q672 Subbase provides system and fan switching, wiring terminals, and mounting base for T872 Thermostat.
- T872 Thermostat has silent dust-free mercury switches operated by coiled bimetal elements.
- Q672 Subbase mounts on wall or horizontal outlet box.
- Adapter plate available for mounting Q672 Subbase on vertical outlet box.
- Heat anticipator(s) are adjustable or fixed; cooling anticipator(s) are fixed.
- External levers and scale for temperature setting located on top of thermostat case.
- Cover thermometer on most T872 Thermostat models.
- Locking cover and locking lever screws available for T872 Thermostats.
- Plastic thermostat guards available for T872 Thermostats.
- Key lock cover with tumbler lock available for T872 Thermostats.



T872A-H, M,Q,R,T Q672A-G,K,L,N

Form Number 60-2116-2

N.J.
REV. 11-76 (.259)

SPECIFICATIONS

SUPER TRADELINE / TRADELINE MODELS

Super Tradeline controls offer features not available on Tradeline or standard models, and are designed to replace a wide range of Honeywell and competitive controls.

Tradeline models are selected and packaged to provide ease of stocking, ease of handling, and maximum replacement value. Specifications of Super Tradeline and Tradeline controls are the same as those of standard models except as noted below.

SUPER TRADELINE MODELS

T872 THERMOSTAT

T872D1300 Thermostat. Provides 2 stages of heating and 2 stages of cooling.

SUPER TRADELINE FEATURES:

- Includes 130821 Adapter Plate Assembly for mounting T872-Q672 on a vertical outlet box.
- Super Tradeline package with cross reference label and special instruction sheet.
- Super Tradeline thermostat is compatible with all Tradeline switching subbases.
- Super Tradeline model supplied with locking lever and locking cover accessories.
- Includes adjustable temperature locking stops.
- Super Tradeline model with 4 switches replaces T872A-F Tradeline or standard models.

TRADELINE MODELS

T872 THERMOSTAT

T872 Thermostat Tradeline models provide 1- or 2-stage heat and/or cool operation as shown in the chart below.

T872	A	B	C	D	E	F
HEATING STAGES	1	1	2	2	–	2
COOLING STAGES	1	2	1	2	2	–

TRADELINE FEATURES:

- Tradeline package with cross reference label and special instruction sheet.
- T872A model with adjustable temperature locking stops.
- All Tradeline T872 models are supplied with locking lever and locking cover accessories.
- All Tradeline thermostat models are compatible with all Tradeline switching subbase models.

Q672 SUBBASE

Q672 switching subbases provide system and fan switching as listed.

TRADELINE FEATURE:

- Tradeline package with cross reference label and special instruction sheet.

Q672	SYSTEM	FAN
A	Heat-Auto-Cool	Auto-On
B	Heat-Off-Cool	Auto-On
E	Off-Heat-Auto-Cool	Auto-On

(continued on page 3)

ORDERING INFORMATION

WHEN PURCHASING REPLACEMENT AND MODERNIZATION PRODUCTS FROM YOUR TRADELINE WHOLESALER OR YOUR DISTRIBUTOR, REFER TO THE TRADELINE CATALOG OR PRICE SHEETS FOR COMPLETE ORDERING NUMBER, OR SPECIFY–

1. Order number:
   –T872 Thermostat, Tradeline, or Super Tradeline, if desired.
   –Q672 Subbase, Tradeline, if desired.
2. Optional T872 specifications, as required.
3. Optional Q672 specifications, if desired.
4. Accessories, as required.
5. Optional temperature scale range, if desired.

IF YOU HAVE ADDITIONAL QUESTIONS, NEED FURTHER INFORMATION, OR WOULD LIKE TO COMMENT ON OUR PRODUCTS OR SERVICES, PLEASE WRITE OR PHONE:

1. YOUR LOCAL HONEYWELL RESIDENTIAL DIVISION SALES OFFICE (CHECK WHITE PAGES OF PHONE DIRECTORY).
2. RESIDENTIAL DIVISION CUSTOMER SERVICE
   HONEYWELL INC., 1885 DOUGLAS DRIVE NORTH
   MINNEAPOLIS, MINNESOTA 55422 (612) 542-7500

   (IN CANADA–HONEYWELL CONTROLS LIMITED, 740 ELLESMERE ROAD, SCARBOROUGH, ONTARIO M1P 2V9)
   INTERNATIONAL SALES AND SERVICE OFFICES IN ALL PRINCIPAL CITIES OF THE WORLD.

STANDARD MODELS

T872 THERMOSTATS

MODELS: See Table 1.

ELECTRICAL RATING: 24 to 30V ac.

SWITCHING: Coiled bimetal elements operate mercury switches.

TEMPERATURE ADJUSTMENT: Heating and cooling setting levers, with common scale located on top of thermostat base. Common lever for heating and cooling on T872R, 1 cooling lever on T872E, and 1 heating lever on T872F.

TEMPERATURE SCALE RANGE: 44 to 86 F [7 to 30 C], standard; optional ranges available.

THERMOMETER RANGE: 52 to 98 F [11 to 36 C].

CHANGEOVER DIFFERENTIAL: 3 F [2 C] minimum between heating and cooling. Levers may be set apart for greater separation.

INTERSTAGE DIFFERENTIAL:

Standard Models—mechanical differential is 1 F [0.6 C] between heating or cooling stages; operating differential is approximately 1.9 F [1 C] between stages in heating or cooling.

Special Models—have other differential requirements.

FINISH: Silver bronze.

MOUNTING MEANS: T872 Thermostat mounts on Q672 Subbase. Subbase mounts horizontally on wall or outlet box. Mounts on vertical outlet box with optional 130821A Adapter Plate Assembly.

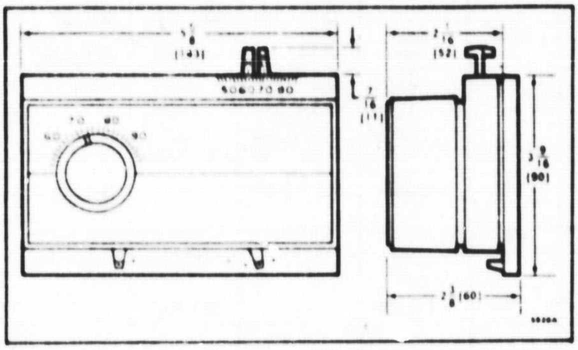


FIG. 1—DIMENSIONS OF T872 THERMOSTAT MOUNTED ON Q672 SUBBASE.

OPTIONAL SPECIFICATIONS (T872 only):

1. Temperature Scale Ranges: 40-75 F [5-24 C] and 75-90 F [24-32 C] with stop, 44-68 F [7-20 C] heating, 80-86 F [27-30 C] cooling, 6-29 C (43-85 F) Celsius scale.
2. Nonadjustable factory added stop. Limits heating set point to 75 F [24 C] maximum, cooling set point to 75 F [24 C] minimum.
3. Celsius scale, 6 to 29 C (43 to 85 F).
4. Customer personalization.
5. Locking cover and locking lever (see Accessories).
6. Thermostat cover less thermometer.
7. Adjustable locking temperature stops.
8. Voltage heat anticipation—first or second stage heat or both (Table 1).
9. Fast cycling on heating stage(s) for electric heat applications.

ACCESSORIES:

1. Locking cover and locking lever assembly Part No. 133627AA with thermometer, 133627AC without thermometer. Includes cover, two screws and Allen wrench for locking cover, plus two No. 4 X 1/4 inch (6.4 millimetre) panhead screws to lock set point levers.
2. Universal thermostat guard—
   - Part No. 133722A, clear plastic cover and beige plastic mounting base.
   - Part No. 133722D, clear plastic cover and clear plastic "ring type" mounting base. Thermostat need not be removed from wall to install guard.
   - Part No. 133723A, beige plastic cover and beige plastic mounting base.
   - Part No. 133723B, beige plastic cover and clear plastic "ring type" mounting base.
3. Key lock cover with tumbler lock—mounts on T872 base and covers thermostat set levers and subbase switches. Two keys included. Should not be used with 130821A or B adapter plate.

● 190103C blank face, internal thermometer.

● 190903D external thermometer.

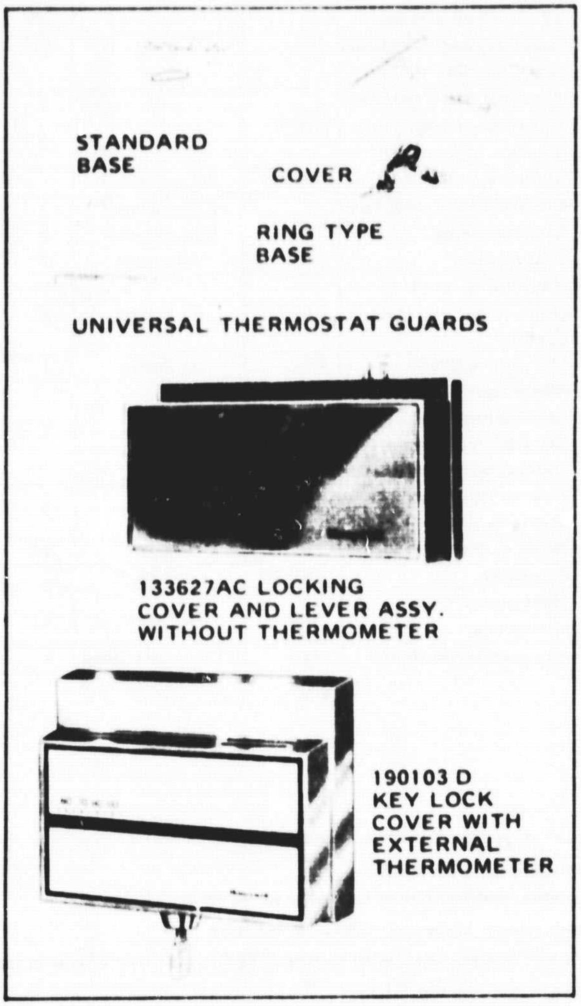


FIG. 2—T872 THERMOSTAT ACCESSORIES.

60-2116—2

TABLE 1–T872 THERMOSTAT SPECIFICATIONS

MODELS AND OPTIONS	RE-PLACES	APPLICATION	SYSTEM STAGES			ANTICIPATION			
			HEAT	COOL	OTHER	HTG (ADJ)		COOLING (FIXED)	
						STAGE 1	STAGE 2	STAGE 1	STAGE 2
T872A–Standard and Tradeline		STD	1	1	–	0.1-1.2A	–	0-1.5A	–
–75 F scaleplate stop w/locking cover		STD	1	1	–	0.1-1.2A	–	0-1.5A	–
–Adj anticipator set .4 amp		STD	1	1	–	0.1-1.2A	–	0-1.5A	–
–Adjustable locking temperature stops (T/L)	T870A	STD	1	1	–	0.1-1.2A	–	0-1.5A	–
–75 F scaleplate stop w/locking cover, no thermometer (for DOD[i]).		STD	1	1	–	0.1-1.2A	–	0-1.5A	–
T872B–Standard and Tradeline		STD	1	2	–	0.1-1.2A	–	0-1.2A	0-1.0A
–Adj anticipator set .4 amp	T870B	STD	1	2	–	0.1-1.2A	–	0-1.2A	0-1.0A
T872C–Standard and Tradeline		STD	2	1	–	0.1-1.2A	0.1-1.2A	0-1.5A	–
–75 F scaleplate stop w/locking cover		STD	2	1	–	0.1-1.2A	0.1-1.2A	0-1.5A	–
–Fast cycling		Elec Heat	2	1	–	0.12-0.6A	0.12-0.6A	0-1.5A	–
–75 F scaleplate stop w/locking cover, no thermometer (for DOD[i]).	T870C	STD	2		–	0.1-1.2A	0.1-1.2A	0.1-1.5A	–
–12 F differential between H1 and H2 stages (T872C1368)		STD	2	1	–	0.1-1.2A	0.1-1.2A	0.1-1.5A	–
T872D–Standard and Tradeline		STD	2	2	–	0.1-1.2A	0.1-1.2A	0-1.2A	0-1.0A
–Adjustable locking temperature stops (T/L)	T870D	STD	2	2	–	0.1-1.2A	0.1-1.2A	0-1.2A	0-1.0A
T872E–Standard and Tradeline	T870E	2-Stage Cool	–	2	–	–	–	0-1.2A	0-1.0A
T872F–Standard and Tradeline		2-Stage Heat	2	–	–	0.1-1.2A	0.1-1.2A	–	–
–Locking cover	T870F	2-Stage Heat	2	–	–	0.1-1.2A	0.1-1.2A	–	–
–Fast cycling		Elec Heat	2	–	–	0.12-0.6A	0.12-0.6A	–	–
T872G–Heat pump, cool changeover, with fast cycling	T870G	Ht Pump	2	1	1[d]	0-1.0A[b]	0.1-1.2A[h]	–	0-1.0A
T872H–Use with Q672C	New	Ht Pump	1	1	1[a]	0-0.8A[b]	–	–	0-0.8A
T872M–Motel heating-cooling application (requires manual changeover remote switching)	T870M	Remote Panel Switching	1	1	1[c]	0.1-1.2A	–	0-1.5A	–
T872N–Heat pump, heat changeover	New	Ht Pump	2	1	1[i]	0.1-1.2A	–	0-1.0A	–
T872Q–Night setback heating	T870Q	STD	1[f]	–	–	0.1-1.2A	–	–	–
T872R–Standard	T870R	Ht Pump[e]	2	1	–	0-1.5A[b]	–	0-1.5A	–
T872S–Heat pump, heat changeover	New	Ht Pump	2	1	–	0.1-1.2A	0.1-1.2A	0-1.0A	–
T872T–Representative model	New	STD–Vent Stage	1	2	1[g]	0.1-1.2A	–	0-1.0A	0-1.0A

[a]Changeover stage operates with cooling.

[b]Fixed voltage type anticipation.

[c]Nonadjustable heating changeover stage set at 60 F (16 C).

[d]Manual changeover stage—use Q672B,L subbase.

[e]Provides night setback used with standard T872 and timer operated remote switching.

[f]Ventilating stage (See Fig. 31.)

[g]Second stage. Also available with fast cycle anticipation (0.12-0.6A) with voltage heater, or without anticipation.

[h]Changeover stage operates with heating.

[i]Department of Defense.

MODELS: See table in form 70-6208.

ELECTRICAL RATING:
Switch contacts–2.5 amp at 30V ac (7.5 amp inrush).
Malfunction light (optional)–24 to 30V ac.

SWITCHES: Two snap-acting switches (one switch, Q672G and K, no switches on Q672D), operated by levers. Switch position is shown on scaleplate.

MOUNTING: Designed to mount horizontally on an outlet box or wall. Adapter plate assembly available for mounting on a vertical outlet box (see Accessories).

FINISH: Silver bronze.

DIMENSIONS in inches [millimetres]: 3-9/16 [90] high; 5-5/8 [142] wide; 5/16 [8] deep (Fig. 1).

OPTIONAL SPECIFICATIONS (Q672 only):

1. Malfunction indicator light with replaceable bulb available on all models. Indicator can show FILTER, CHECK, EM. HT. (emergency heat), or LK. OUT (lockout). Specify indication when ordering.
2. External jumper between R_C-R_H for common heating-cooling transformer. Jumper is field removable.
3. System switching marked HEAT-OFF/RESET-COOL for systems requiring impedance relay reset. Available on Q672B only.
4. "G" terminal isolated on heating to provide fan relay operation from external low voltage fan switch (Q672B only).
5. Auto fan operation on both heat and cool (Q672B only).
6. Common R terminal for heating/cooling.
7. External O and B terminal jumper (Q672G only).
8. Jumper between W2-X2 terminals (Q672F only).
9. Jumper between E-X2 terminals (Q672F only).
10. Changeover in cool or heat made for heat pumps.
11. Auto fan in EM. HT. for heat pumps.

ACCESSORIES:

1. Adapter plate assembly, Part No. 130821A, for mounting on vertical outlet box. Assembly includes adapter ring and cover plate.
2. Adapter plate assembly, Part No. 130821B, for covering old thermostat marks on wall. Cover plate only.
3. Indicator replacement bulb, Part No. 129571.
4. Field addable indicator light assembly, Part No. 135734A. Assembly includes retainer plate, 2 self-tapping screws, light bulb with 2-3/4 inch [70 millimetres] leadwires with spade terminals and lenses. The Q672 lenses indicate FILTER, CHECK or EM. HT.

INSTALLATION

CAUTION

1. Installer must be a trained, experienced serviceman.
2. Disconnect power supply to prevent electrical shock and equipment damage.
3. Do NOT short across coil terminals on relay. This may burn out the heat anticipator.
4. Run wires as close to the subbase as possible. To prevent interference with the thermostat linkage, keep wire length to a minimum, and make certain wires do NOT protrude outward beyond standoffs (Fig. 5). Push excess wire back into the hole, and plug hole to prevent drafts from affecting thermostat operation.
5. Do NOT overtighten thermostat captive mounting screws. This may damage the threads in the subbase.
6. Always conduct a thorough checkout when installation is complete.

IMPORTANT

Thermostats are calibrated at the factory using subbases mounted at true level. Inaccurate subbase leveling will cause thermostat control deviation.

LOCATION

Locate the thermostat about 5 feet [1.5 metre] above the floor in an area with good air circulation at average temperature.

Do not mount the thermostat where it may be affected by–

–drafts, or dead spots behind doors and in corners.
–hot or cold air from ducts.
–radiant heat from the sun or appliances.
–concealed pipes and chimneys.
–unheated (uncooled) areas behind the thermostat.

SUBBASE MOUNTING

The subbase is designed for mounting on a wall or horizontal outlet box. (Adapter assembly, Part No. 130821B, with cover plate only is available for covering wall marks from old thermostat.) An adapter assembly, Part No. 130821A, with adapter ring and cover plate is available for mounting on a vertical outlet box. To mount subbase, proceed as follows:

1. At the location selected, prepare an opening for the thermostat wires.
2. Run low voltage thermostat wires to the location, and pull about 4 inches [100 millimetres] through the wall opening.

NOTE: Use color-coded thermostat cable for proper wiring.

3. If mounting the subbase on a vertical outlet box (Fig. 3), install the adapter ring with the 2 screws provided.

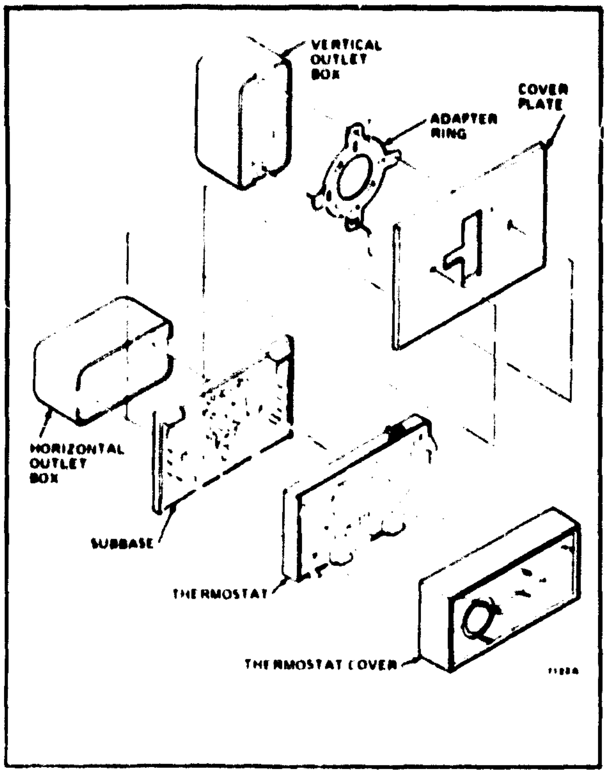


FIG. 3—INSTALLATION OF Q672 SUBBASE ON OUTLET BOX.

4. Pull thermostat cable through cover plate (if used) and subbase opening. Secure the cover plate and subbase with the 2 screws provided, but do not tighten.

Thermostats are calibrated at the factory using subbases mounted at true level. Inaccurate subbase leveling will cause thermostat control deviation.

5. The subbase mounting slots provide for minor out of level adjustments. Level the subbase using a spirit level, as shown in Fig. 4 and tighten subbase mounting screws.

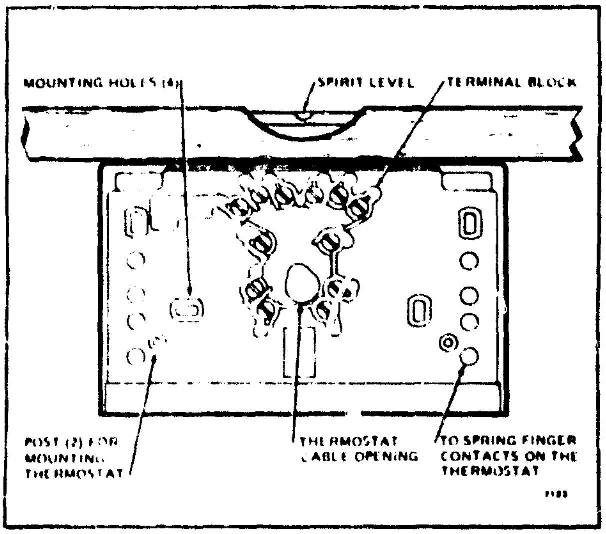


FIG. 4—LEVELING THE SUBBASE.

WIRING

All wiring must comply with local electrical codes and ordinances.

A letter code is near each terminal for easy identification. Typical terminal designation and wiring connections are listed in Tables 2 and 3.

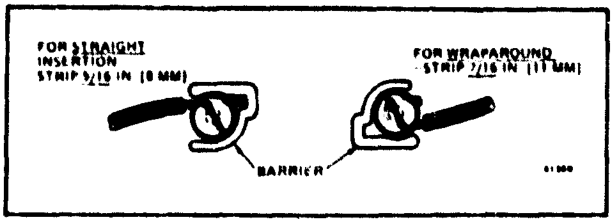


FIG. 5—BARRIER CONFIGURATION.

TABLE 2—TERMINAL DESIGNATIONS

TERMINAL	TYPICAL CONNECTION
B	Heating damper motor; changeover valve (if used).
E	Emergency heat relay.
G	Fan relay coil.
O	Cooling damper motor; changeover valve (if used).
R	Power connection to transformer (internally connected for cooling and heating).
R_C	Power connection to cooling transformer.
R_H	Power connection to heating transformer.
W_1	Stage 1 heating control.
W_2	Stage 2 heating control.
Y_1	Stage 1 cooling control.
Y_2	Stage 2 cooling control.
X-A1-A2-C	Clogged filter switch.

TABLE 3—ALTERNATE CONTROL CIRCUIT TERMINAL DESIGNATIONS

ALTERNATE DESIGNATIONS		STANDARD DESIGNATION	TYPICAL CONNECTION
V	V	R	24 volt power supply
H1	—	W1	First stage heating
H2	Y	W2	Second stage heating
C1	M	Y1	First stage cooling
C2	—	Y2	Second stage cooling
F	F	G	Fan
—	—	B	Heating changeover
—	R	O	Cooling changeover

The shape of the terminal barrier permits insertion of straight or conventional wrap-around (Fig. 5) wiring connections. Either method is acceptable. When making connections, strip wire to the length specified in Fig. 5.

Follow the equipment manufacturer's wiring instructions, if available, when wiring the subbase. If not available, Figs. 15 and up show typical T872-Q672 system hookups.

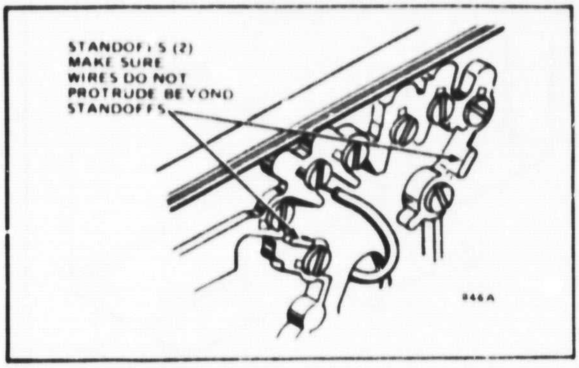


FIG. 6–INDIVIDUAL SCREW WIRING FOR Q672 SUBBASE.

Run wires as close to the subbase as possible. To prevent interference with the thermostat linkage, keep wire length to a minimum, and make certain wires do NOT protrude outward beyond standoffs, (Fig. 6). Push excess wire back into the hole, and plug hole to prevent drafts from affecting thermostat operation.

HEAT ANTICIPATOR SETTING

Set the heat anticipator scale to match the primary control rating. When using a T872 Thermostat with 2 stages of heating, set both heat anticipators to match their respective primary control rating. If the primary control nameplate has no rating or if further adjustment is necessary, use the following procedure to determine the current draw of each stage.

The current draw of each heating stage must be measured with the thermostat removed.

1. Connect an ac ammeter of appropriate range between the heating terminals of the subbase—
   Stage 1—between W1 and RH or R;
   Stage 2—between W2 and RH or R.
2. Move the system switch to HEAT or AUTO.
3. After 1 minute, read the ammeter and *record* the reading.
   Stage 1— amp;
   Stage 2— amp.
4. After mounting the thermostat (see Thermostat Mounting, next paragraph), set the adjustable heat anticipator to match the respective reading measured in step 3.

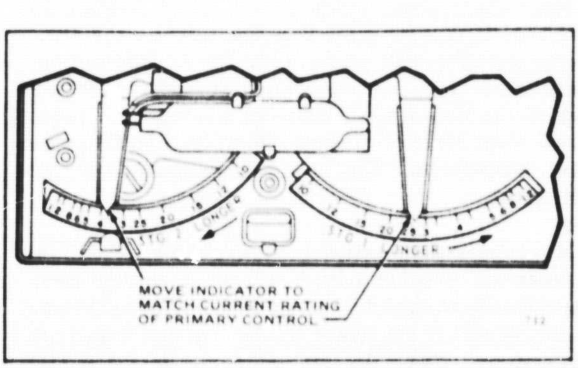


FIG. 7–ADJUSTABLE HEAT ANTICIPATOR SCALES.

If equipment cycles too fast, set the anticipator to a higher current rating, not more than 1/2 division at a time, and recheck cycle rate. Most conventional 2-stage heating equipment is designed to operate at 3 cycles per hour, and 1-stage heating equipment at 6 cycles per hour, at 50 percent load conditions. When using a T872 Thermostat in heat pump systems, set the heat anticipator at 140% of the actual primary control current draw to reduce the cycling rate.

Most heat pump systems should cycle 2-1/2 to 3 times per hour.

THERMOSTAT MOUNTING

1. Remove the thermostat from the polystyrene shipping container.
2. Remove the thermostat cover by pulling the bottom edge of the cover upward until it snaps free of the locking springs.

NOTE: The cover is hinged at the top and must be removed by pulling up at the bottom.

3. Carefully remove and discard the polystyrene packing insert which protects the mercury switches during shipment.
4. Turn the thermostat base over and note the spring fingers which engage the subbase contacts. Make sure the spring fingers are NOT bent preventing proper electrical contact with the subbase.

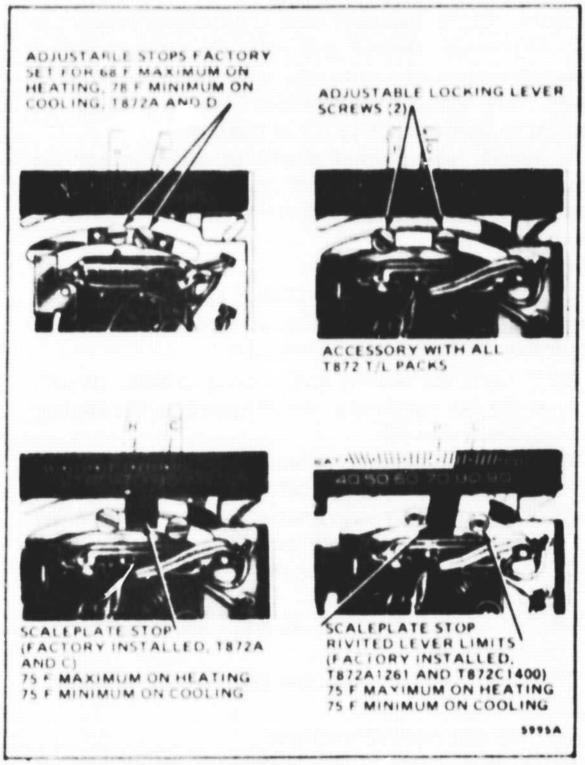


FIG. 8–RANGE LIMITING AND LEVER LOCKING METHODS.

5. Set the heat anticipator indicator(s), Fig. 7, to the respective current setting of each stage. See Heat Anticipator Setting.

6. If the thermostat provides the optional locking lever assembly, install the 2 self-tapping screws (Fig. 8) in the lever arms, if desired.

7. If the thermostat provides optional locking cover assembly, start the 2 Allen locking screws in the cover with the wrench provided (Fig. 9).

8. Note the tabs along the top inside edge of the thermostat base. The tabs fit the subbase sockets. Hang the thermostat on the subbase and tighten the captive mounting screws (Figs. 3-4) on the thermostat base. Do NOT overtighten thermostat captive mounting screws. This may damage the threads in the subbase.

9. Hang the upper edge of the thermostat cover on the base and swing cover downward until it engages with spring clips on base. Tighten the locking cover screws, if assembly is provided.

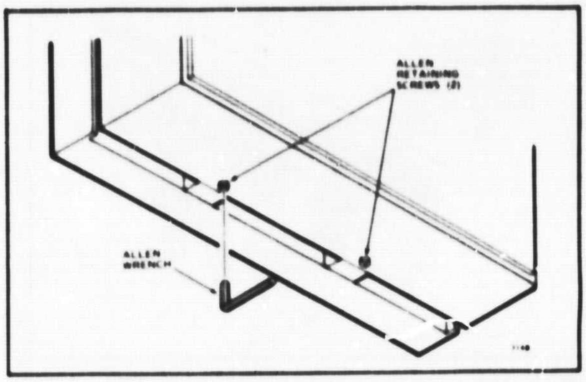


FIG. 9—INSTALLATION LOCKING COVER SCREWS ASSEMBLY.

SETTING AND CHECKOUT

CAUTION

On systems using a gas valve, never apply a jumper across the valve coil terminals, even temporarily. This may burn out thermostat heat anticipator(s).

SETTING

TEMPERATURE SETTING

Move the H (heating) and C (cooling) levers (see Fig. 10) to the desired positions. On models with 2 stages of heating or cooling, the same lever controls both stages. The minimum differential between heating and cooling set points is 3 F [2 C] at midscale.

If model has optional screws to lock temperature control levers, loosen these screws before making temperature adjustment; tighten when levers are set at desired position.

SUBBASE SETTING

SYSTEM SWITCHING positions control thermostat operation as follows (see listing of models for positions applicable to model being installed):

- OFF—both the heating and cooling systems are off. If the fan switch is at AUTO position, the cooling fan is also off.
- HEAT—heating system is controlled by the thermostat. Cooling system is off.
- AUTO—completely automatic heating or cooling controlled by the thermostat.
- COOL—thermostat controls the cooling system. Heating system is off.
- EM. HT.—emergency heat relay is energized. Cooling system is off.

FAN SWITCHING positions control fan operation as follows:

- ON—fan operates continuously.
- AUTO—fan operates with cooling equipment as controlled by the thermostat or with the heating equipment as controlled by the plenum switch.

CHECKOUT

HEATING

Move the system switch on the Q672 Subbase to HEAT or AUTO. Move the H lever on the T872 (Fig. 10) about 10 F [6 C] above room temperature. Both stages of heating system should start and the fan should run after a short delay. Move the H lever about 10 F [6 C] below room temperature. The heating equipment should shut off, and the fan should run for a short time, then shut off.

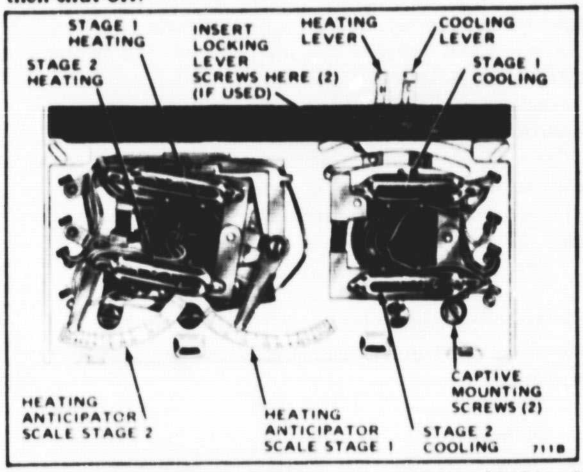


FIG. 10—INTERNAL VIEW OF T872D (WITH 2 STAGES OF HEATING AND COOLING).

COOLING

Move the system switch on the Q672 Subbase to COOL or AUTO. Move the C setting lever on the T872 Thermostat (Fig. 10) about 10 F [6 C] below room temperature. The cooling equipment and fan should start. If the system has 2 stages of cooling, both stages should start. Move the C lever about 10 F [6 C] above room temperature. The cooling equipment and fan should stop.

FAN

Move the system switch to COOL, OFF, or AUTO. If necessary, position both temperature setting levers near midscale so that the heating and cooling equipment are off. Move the fan switch to ON. The fan should run continuously. When the fan switch is in the AUTO position, fan operation is controlled by the heating or cooling system.

SERVICE

CAUTION

Before servicing, disconnect power supply to prevent electrical shock or equipment damage.

THERMOSTAT

T872 Thermostats are accurately calibrated at the factory; THEY DO NOT HAVE PROVISION FOR FIELD CALIBRATION.

THERMOMETER

To calibrate the thermometer:

1. Remove thermostat cover by pulling up from the bottom until it clears the locking springs. If cover has optional locking screws, these must be backed out before cover can be removed.
2. Set the cover on a table near an accurate thermometer.
3. After allowing 5 or 10 minutes for stabilization, compare the readings. If they are the same, replace cover and put system into operation. If they are different, recalibrate the thermostat thermometer, step 4.
4. Insert a small screwdriver in the thermometer shaft (Fig. 11) and turn it until the thermometers read the same. When thermometer is calibrated, replace cover and place system and fan switches for desired operation.

NOTE: Hand heat will offset the thermometer reading. After making each adjustment, wait 5 or 10 minutes for the thermometer to stabilize before comparing.

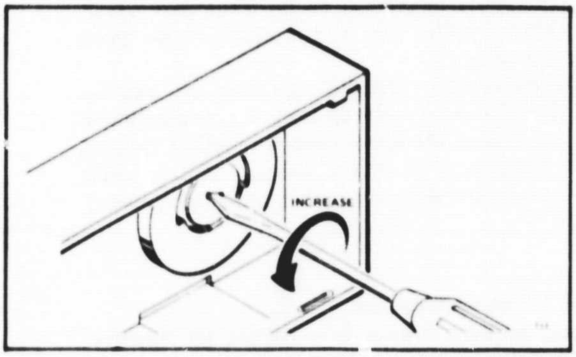


FIG. 11—THERMOMETER CALIBRATION.

BULB REPLACEMENT

Before replacing bulb, shut off the power supply to prevent shorting out the transformer at the bulb terminals, or move subbase system switch to "OFF."

Replace bulb in subbases with optional malfunction light as follows.

1. Remove the thermostat from the subbase.
2. Remove the snap-on shield that covers the light.
3. Disconnect the field wire from the "X" terminal to prevent shorting out the transformer at the bulb terminals.
4. Snap out the old bulb and replace it with a new bulb, Part No. 129571. The bulb contact should seat in the depression in the socket base. The bulb may be screwed in farther, if necessary, for a better electrical connection. When installing bulb, use needlenose pliers.
5. Reconnect the field wire to terminal "X."
6. Replace the shield and mount the thermostat.

INDICATOR LIGHT ASSEMBLY INSTALLATION

The 135734A Indicator Light Assembly may be field added to most Q672 Subbases. The assembly mounts directly on the subbase and may be installed before or after the subbase is mounted. To install the indicator light assembly, use the following procedure.

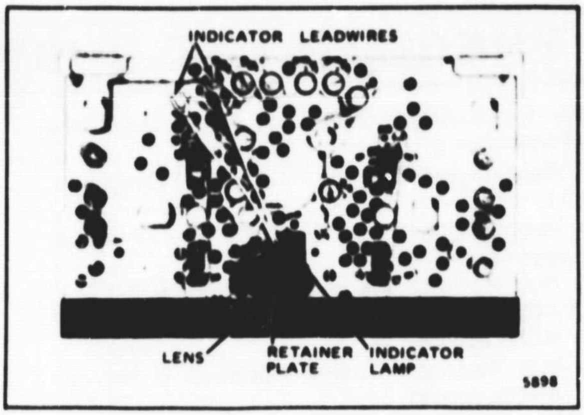


FIG. 12—INSTALLATION OF INDICATOR LIGHT ASSEMBLY.

1. If the thermostat is mounted on the Q672 Subbase, remove the thermostat cover. NOTE: If the cover has optional locking screws, these must be backed out before cover can be removed.
2. Loosen 2 captive screws and remove thermostat.
3. Select either FILTER, CHECK, or EM. HT. lens.
4. Place the lens over the recess cavity on the subbase, and place the black retainer plate over the lens.
5. Start 1 self-tapping screw through the left-hand hole of the retainer plate and lens.
6. Pivot lens and plate out of way as shown in Fig. 12. Insert bulb into recessed cavity, and route wires toward left-hand side of subbase.
7. Pivot lens and retainer plate into position, and start second self-tapping screw in right-hand retainer hole.

To wire indicator light assembly, use the following procedure.

1. Route 1 indicator light leadwire to the R or RH subbase terminal, and fasten beneath the terminal screw (Fig. 13).

2. Route second indicator light leadwire to right retainer screw.

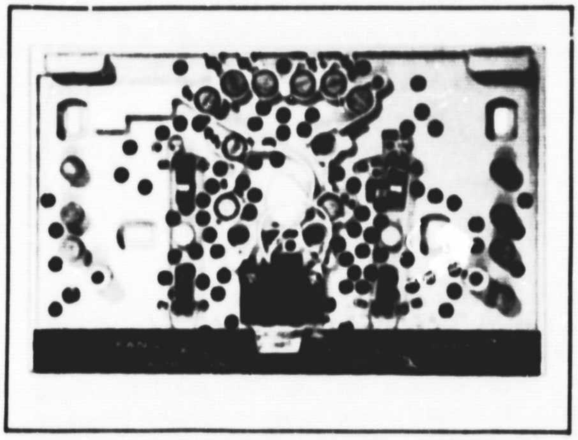


FIG. 13—CONNECTING 135734A LEADWIRES.

3. Route wire from indicator light control switch to right retainer screw. Attach both indicator switch wire and indicator light leadwire to right retainer screw.

4. Connect remaining indicator light control switch wire to common secondary leg of heating transformer (Fig. 14).

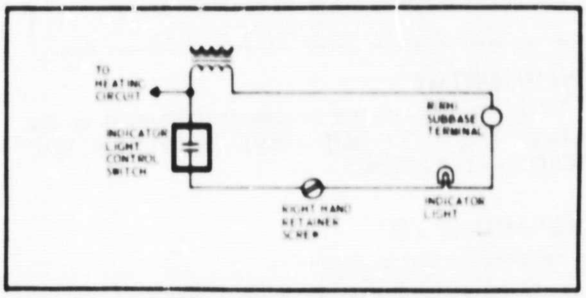


FIG. 14--WIRING HOOKUP FOR INDICATOR LIGHT AND CONTROL SWITCH.

Remount the thermostat, and restore the power supply. To check indicator light operation, jumper the indicator light control. The indicator lamp should light. After removing the jumper, the lamp should go out.

THERMOSTAT-SUBBASE APPLICATION

The schematics on the following pages are divided into four groups:

1. Standard circuits with AUTO heat-cool changeover, page 11.
2. Standard circuits with MANUAL heat-cool changeover, page 17.
3. Heat Pump circuits with changeover in cooling—
   AUTO, page 21.
   MANUAL, page 28.
4. Heat Pump circuits with changeover in heating—
   AUTO, page 32.

Within groups, schematics are generally arranged alphabetically by subbase model, then thermostat model. For additional information on Q672 Subbase/T872 Thermostat combinations, see form 70-6208.

Circuit descriptions and terminology is defined as follows.

For standard heating-cooling circuits:

AUTO CHANGEOVER—refers to the presence of an AUTO position in the system switching (EXAMPLE: Q672E with OFF-HEAT-AUTO-COOL switching); does not require switch movement to change mode.

MANUAL CHANGEOVER—requires a system switch movement to change mode. (EXAMPLE: Q672B with HEAT-OFF-COOL switching).

T872D thermostats with 2 heat and 2 cool switches are shown on most standard circuits. Most standard or Tradeline subbases (Q672 A-E, G) can be used with T872A-F standard Tradeline thermostats. The schematics can be field-modified as required.

For heat pump circuits:

CHANGEOVER VALVE—operates on Cooling. The reversing valve or relay is activated either by moving the system switch to COOL (manual changeover) or by a mercury switch which makes on a temperature rise (auto changeover).

CHANGEOVER VALVE—operates on heating. The reversing valve or relay is activated either by moving the system switch to HEAT (manual changeover) or by a mercury switch which makes on a temperature fall (auto changeover.)

For all circuit components:

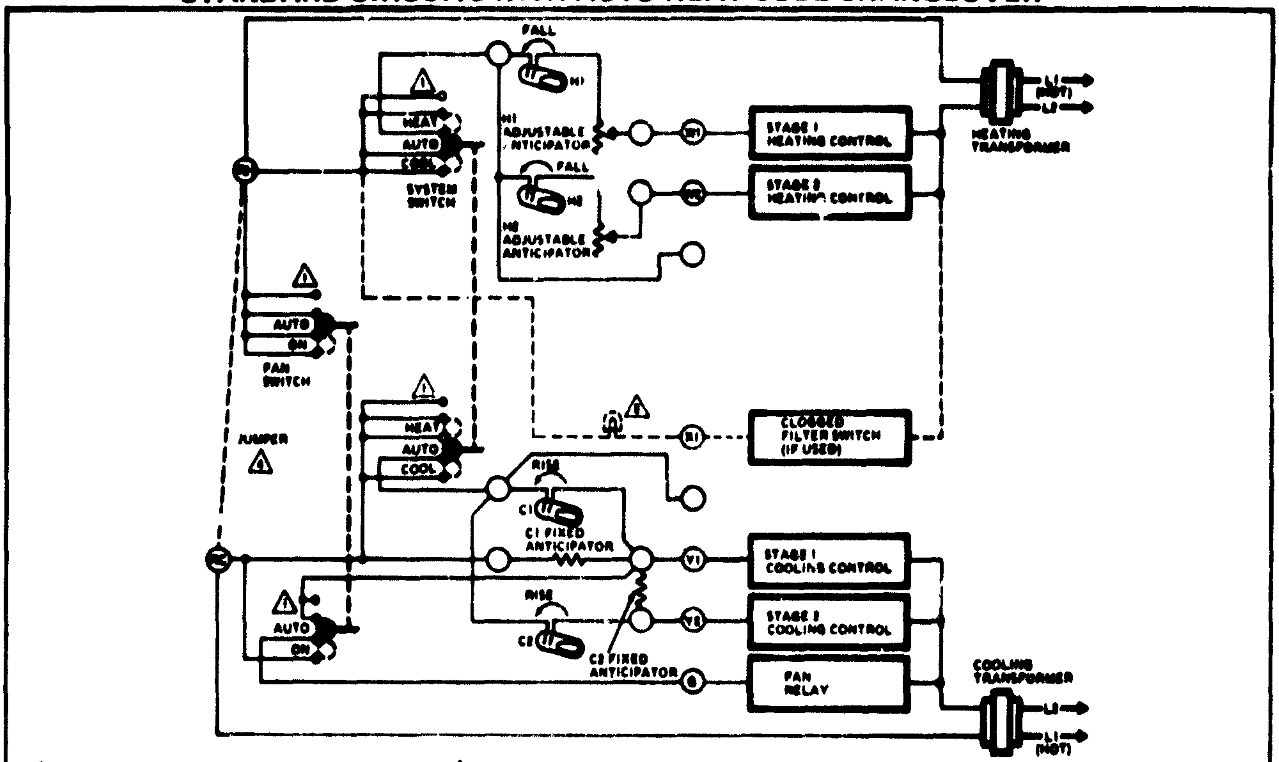
Each mercury switch is identified by function, as follows:

H1—Stage 1 heating
H2—Stage 2 heating
C1—Stage 1 cooling
C2—Stage 2 cooling
C/O—Changeover (heat pumps)

Each anticipator is identified as adjustable or fixed, as well as naming which switch it affects. FOR EXAMPLE: H1 adjustable anticipator, C1 fixed anticipator.

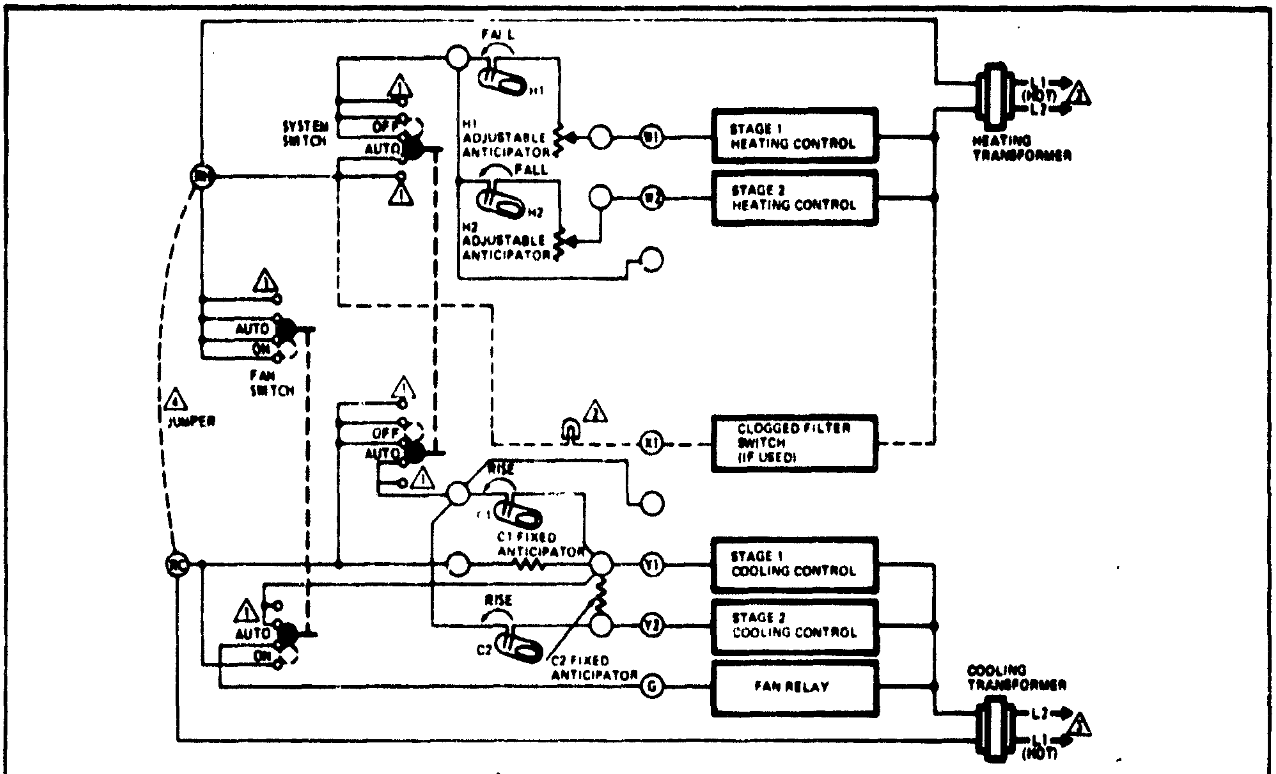
All T872 thermostats use mercury switches. Each schematic will indicate switch operation by being drawn in the open position with an arrow indicating operation with a temperature RISE or FALL.

STANDARD CIRCUITS WITH AUTO HEAT-COOL CHANGEOVER



1. SWITCHING TO DESIGNATED POSITIONS ONLY.
2. FACTORY ADDED MALFUNCTION LIGHT (OPTIONAL)
3. POWER SUPPLY. PROVIDE DISCONNECT MEANS AND OVERLOAD PROTECTION AS REQUIRED.
4. FIELD-REMOVABLE, JUMPER (OPTIONAL). REMOVE FOR SEPARATE HEATING AND COOLING TRANSFORMERS.

FIG. 15—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672A SUBBASE WITH T872D THERMOSTAT. SUBBASE PROVIDES HEAT-OFF-COOL SYSTEM AND AUTO-ON FAN SWITCHING.



1. SWITCHING TO DESIGNATED POSITIONS ONLY.
2. FACTORY ADDED MALFUNCTION LIGHT (OPTIONAL)
3. POWER SUPPLY. PROVIDE DISCONNECT MEANS AND OVERLOAD PROTECTION AS REQUIRED.
4. FIELD REMOVEABLE JUMPER (OPTIONAL). REMOVE FOR SEPARATE HEATING-COOLING TRANSFORMERS.

FIG. 16—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672C SUBBASE WITH T872D THERMOSTAT. SUBBASE PROVIDES OFF-AUTO SYSTEM AND AUTO-ON FAN SWITCHING.

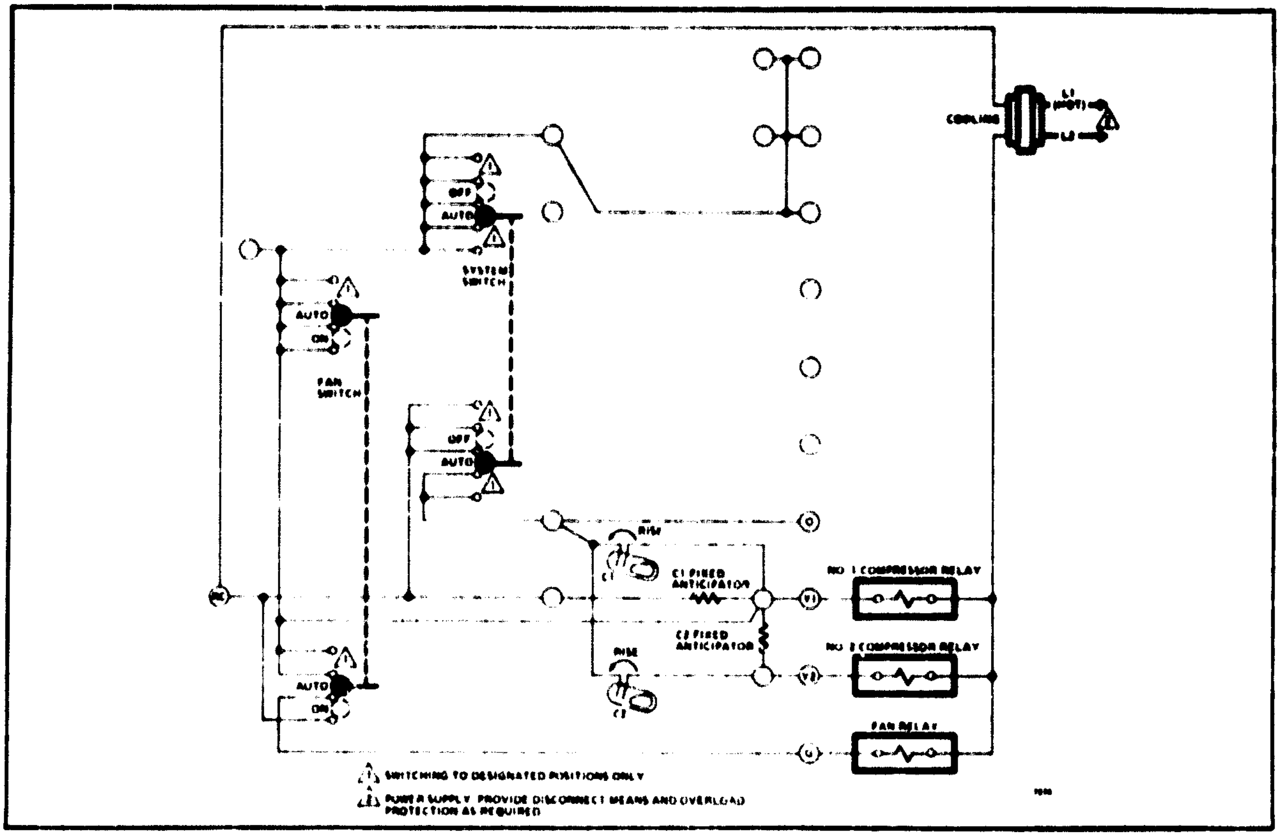


FIG. 17—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672C SUBBASE WITH T872E THERMOSTAT. SUBBASE PROVIDES OFF-AUTO AND AUTO-ON FAN SWITCHING. RC TERMINAL FOR COOLING ONLY.

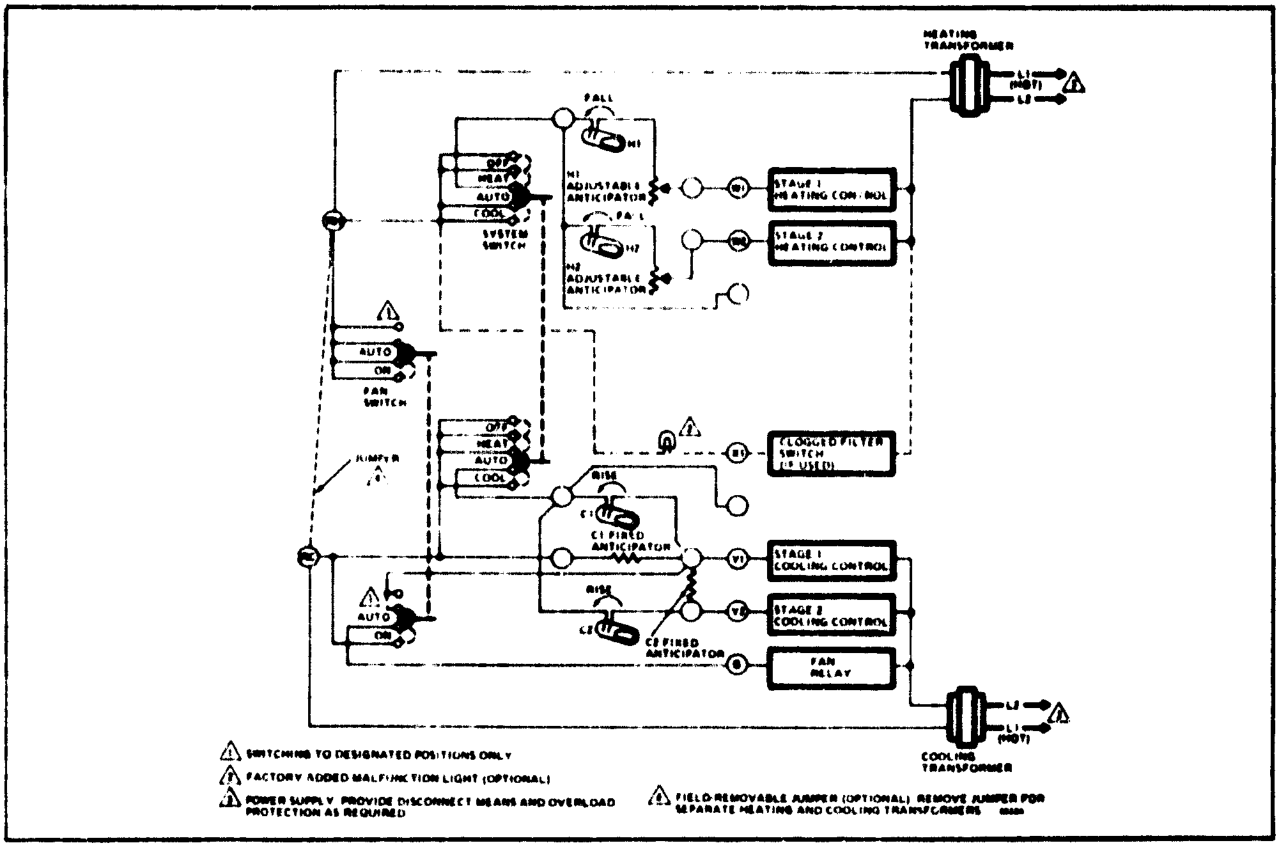


FIG. 18—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672E SUBBASE WITH T872D THERMOSTAT. SUBBASE PROVIDES OFF-HEAT-AUTO-COOL SYSTEM AND AUTO-ON FAN SWITCHING. RC-RH TERMINALS FOR SEPARATE HEATING AND COOLING CIRCUITS.

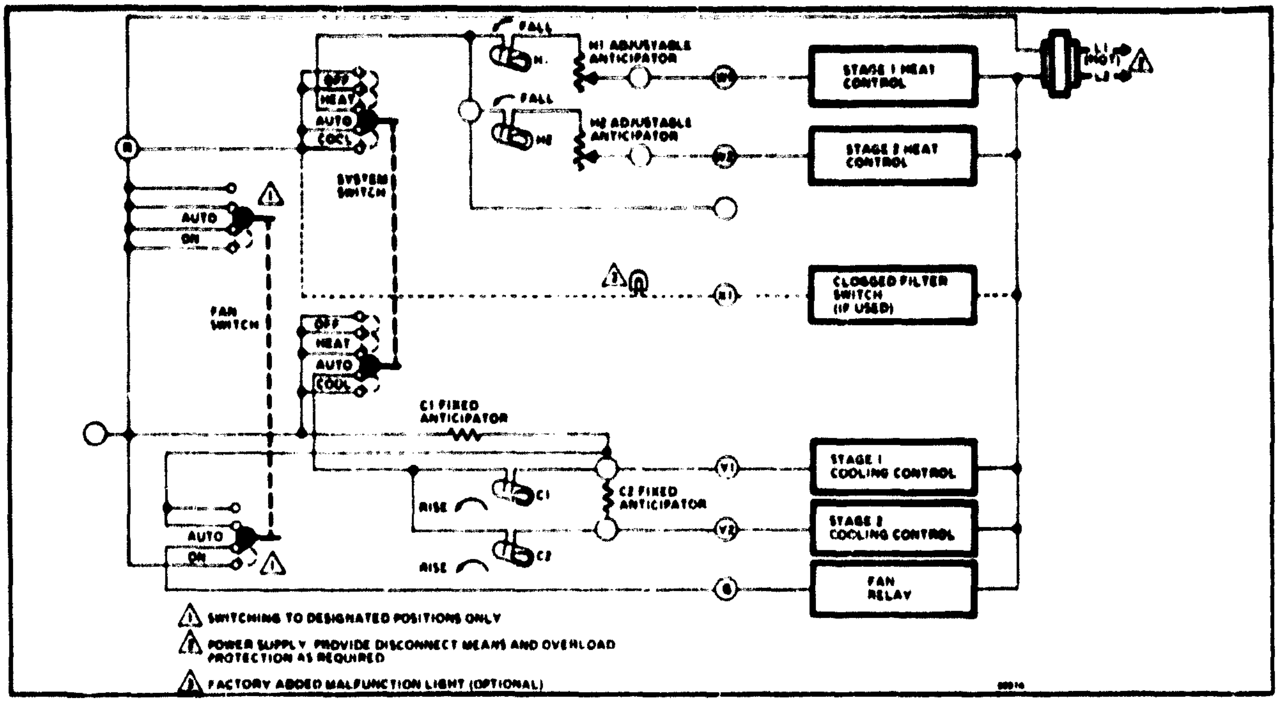


FIG. 19—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672E SUBBASE WITH T872D THERMOSTAT. SUBBASE PROVIDES OFF-HEAT-AUTO-COOL SYSTEM AND AUTO-ON FAN SWITCHING. R TERMINAL FOR COMMON HEATING AND COOLING CIRCUIT.

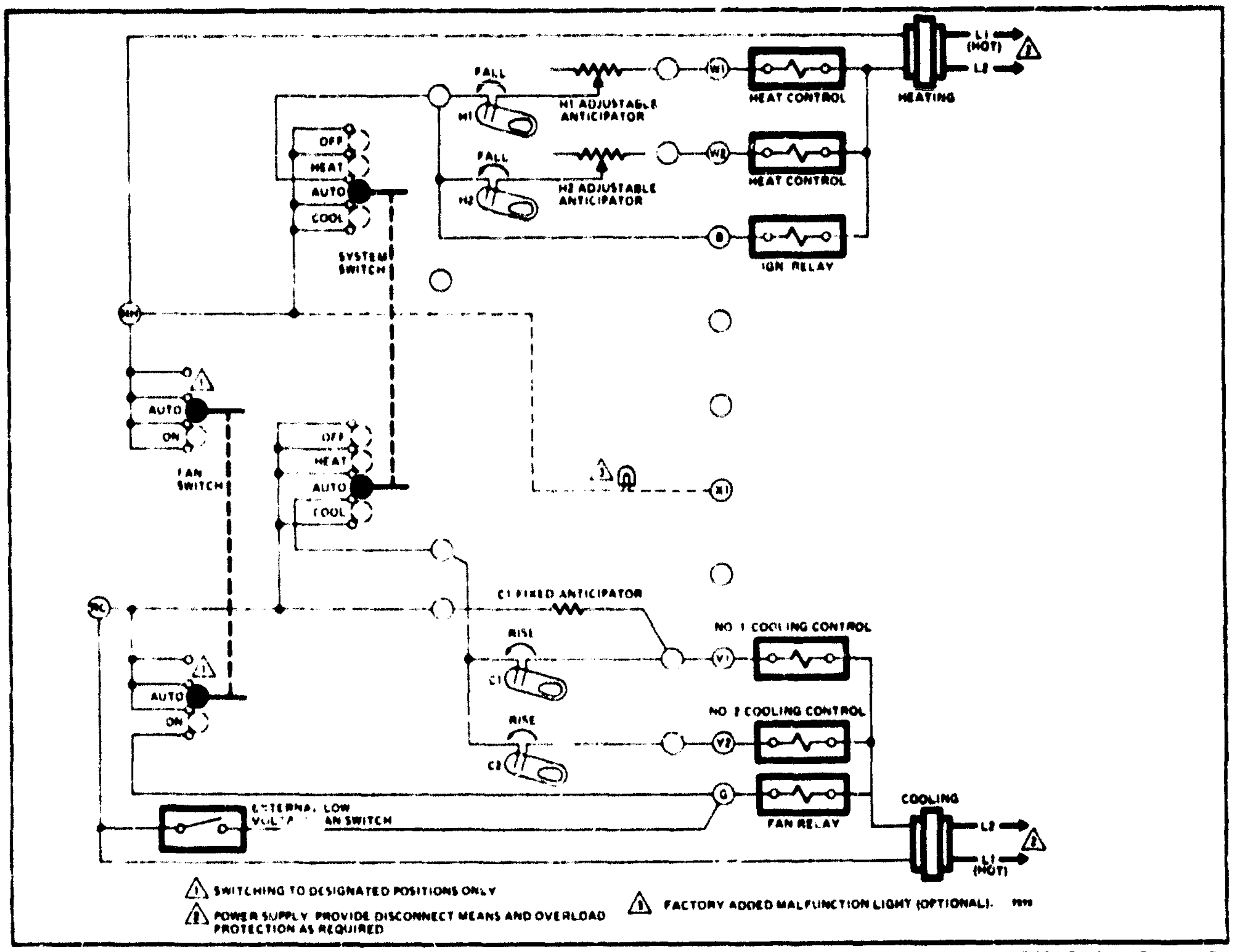


FIG. 20—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672E SUBBASE AND T872D THERMOSTAT. SUBBASE PROVIDES OFF-HEAT-AUTO-COOL SYSTEM AND AUTO-ON FAN SWITCHING. RC-RH TERMINALS FOR SEPARATE HEATING AND COOLING CIRCUITS.

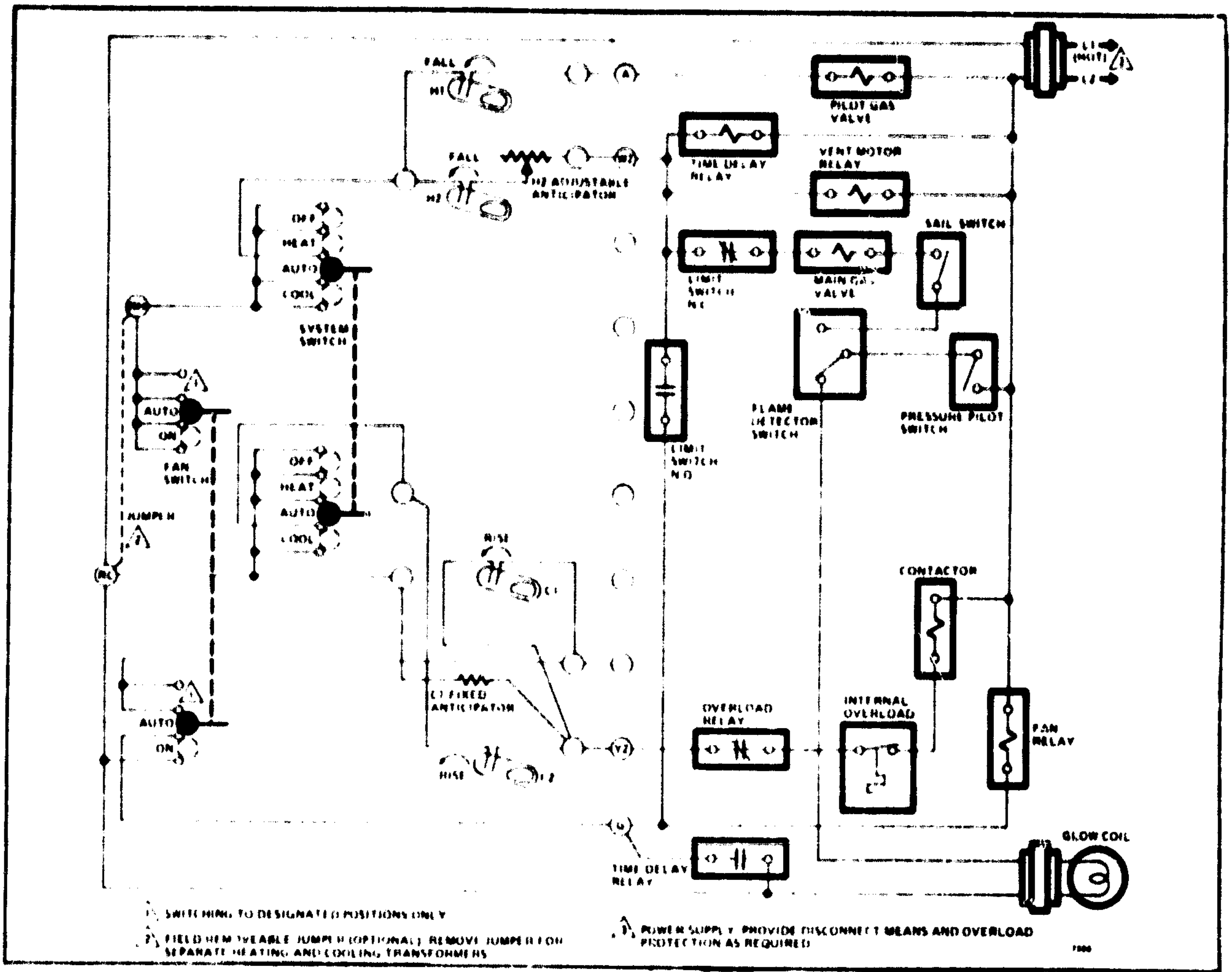


FIG. 21—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672E SUBBASE AND T872D THERMOSTAT. SUBBASE PROVIDES OFF-HEAT-AUTO-COOL SYSTEM AND AUTO-ON FAN SWITCHING.

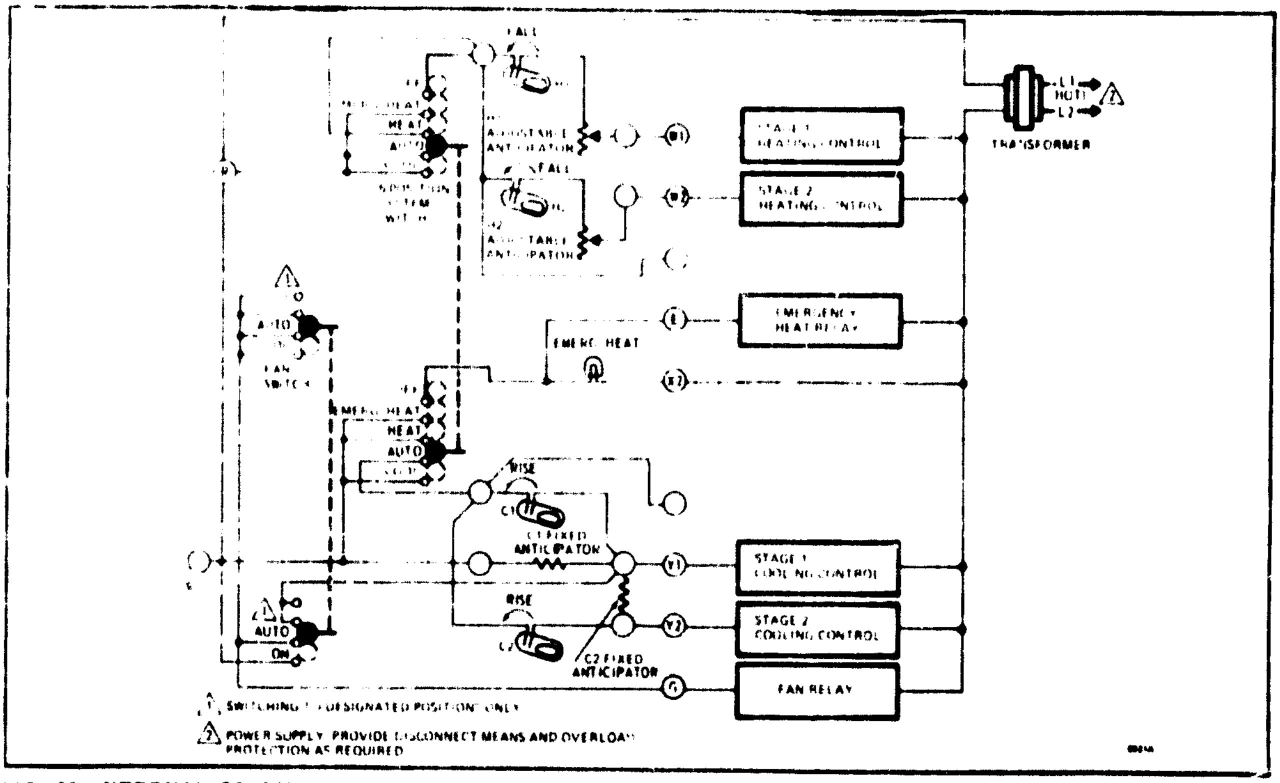


FIG. 22—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672F SUBBASE AND T872D THERMOSTAT. SUBBASE PROVIDES OFF-EM.HT-HEAT-AUTO-COOL SYSTEM AND AUTO-ON FAN SWITCHING. EMERGENCY HEAT RELAY AND LIGHT ARE ENERGIZED WHEN SWITCH IS IN EM. HT. POSITION.

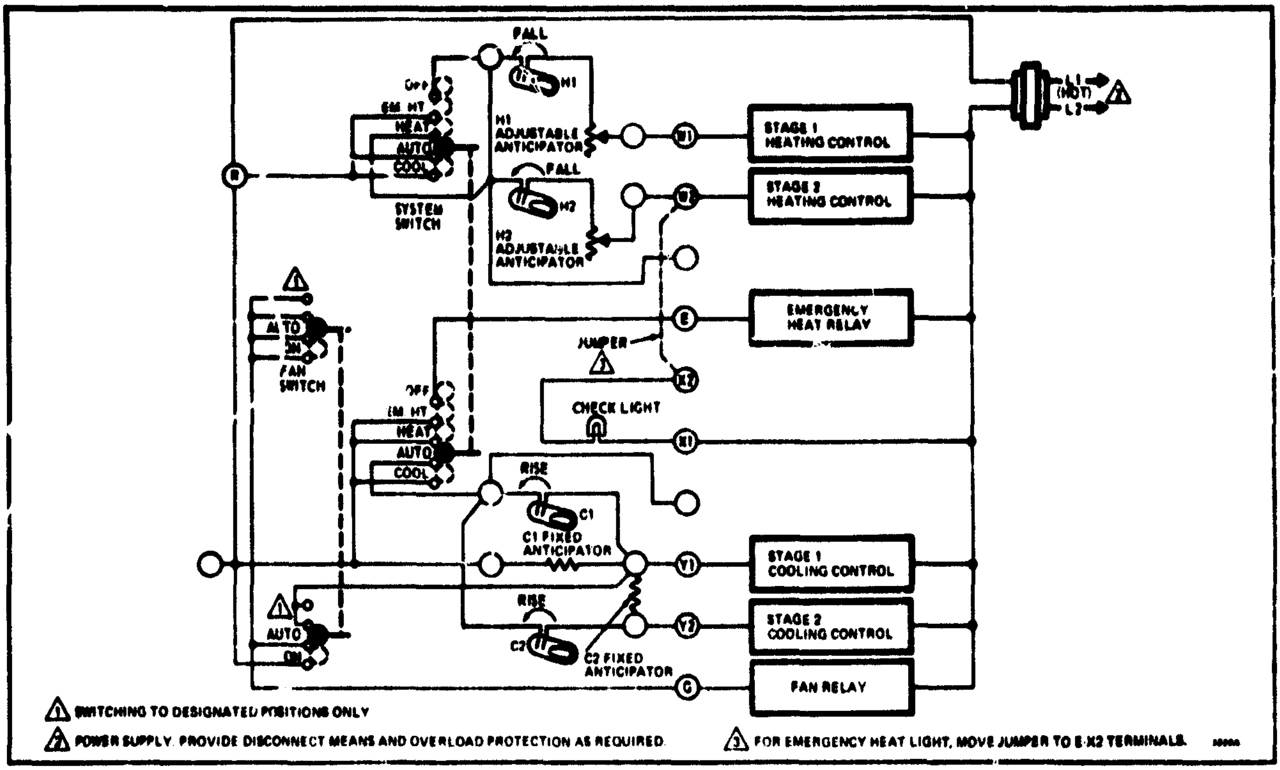


FIG. 23—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672F SUBBASE AND T872D THERMOSTAT. SUBBASE PROVIDES OFF-EM. HT.-HEAT-AUTO-COOL SYSTEM AND AUTO-ON FAN SWITCHING. EMERGENCY HEAT RELAY IS ENERGIZED WHEN SYSTEM SWITCH IS IN EM. HT. POSITION; LIGHT OPERATES WITH SECOND STAGE OF HEATING.

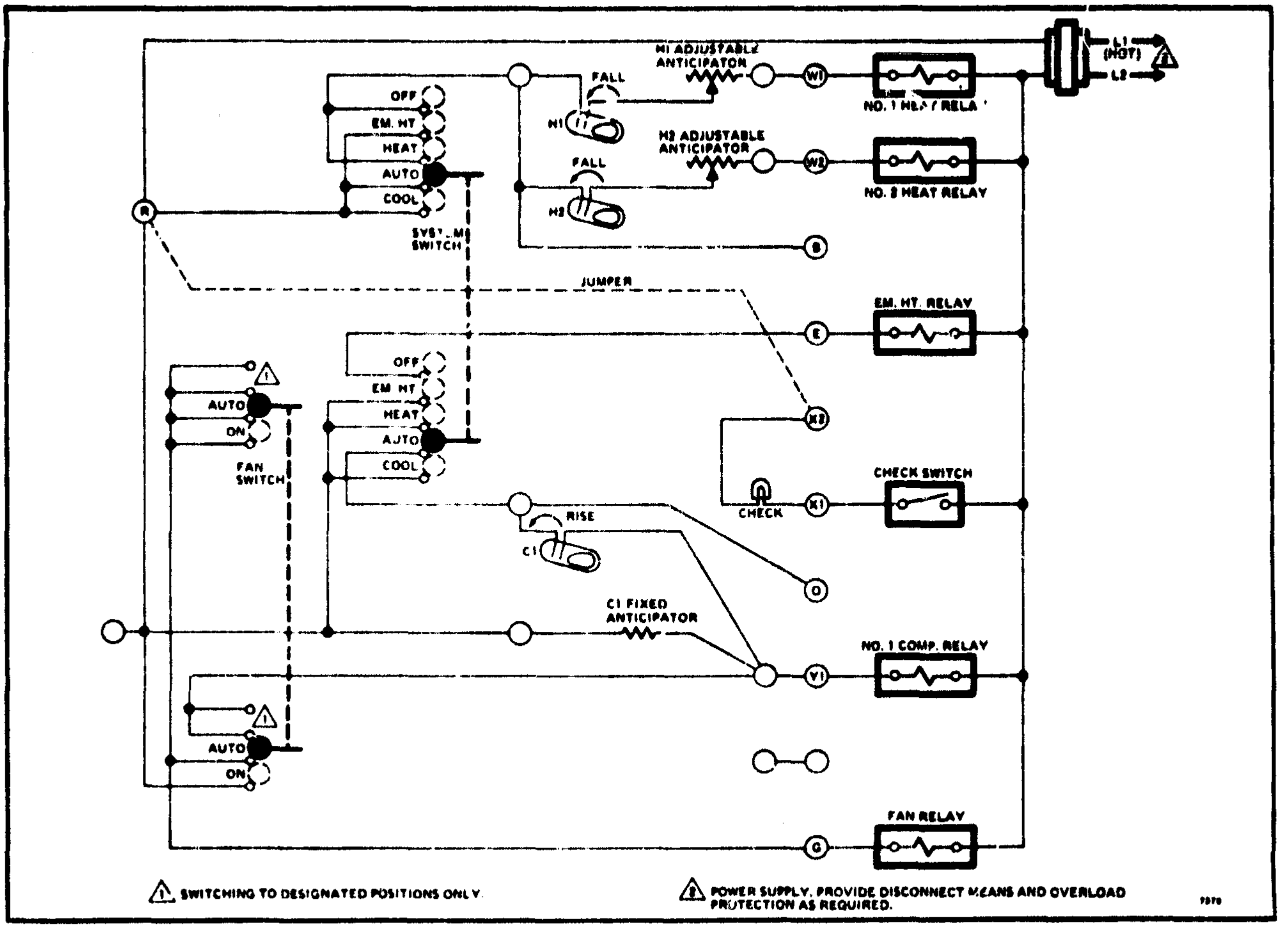


FIG. 24—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672F SUBBASE WITH T872C THERMOSTAT. SUBBASE PROVIDES OFF-EM. HT.-HEAT-AUTO-COOL SYSTEM AND AUTO-ON FAN SWITCHING. EMERGENCY HEAT RELAY ENERGIZED WHEN SWITCH IS IN EM. HT. POSITION; LIGHT OPERATES WITH SECOND STAGE HEATING.

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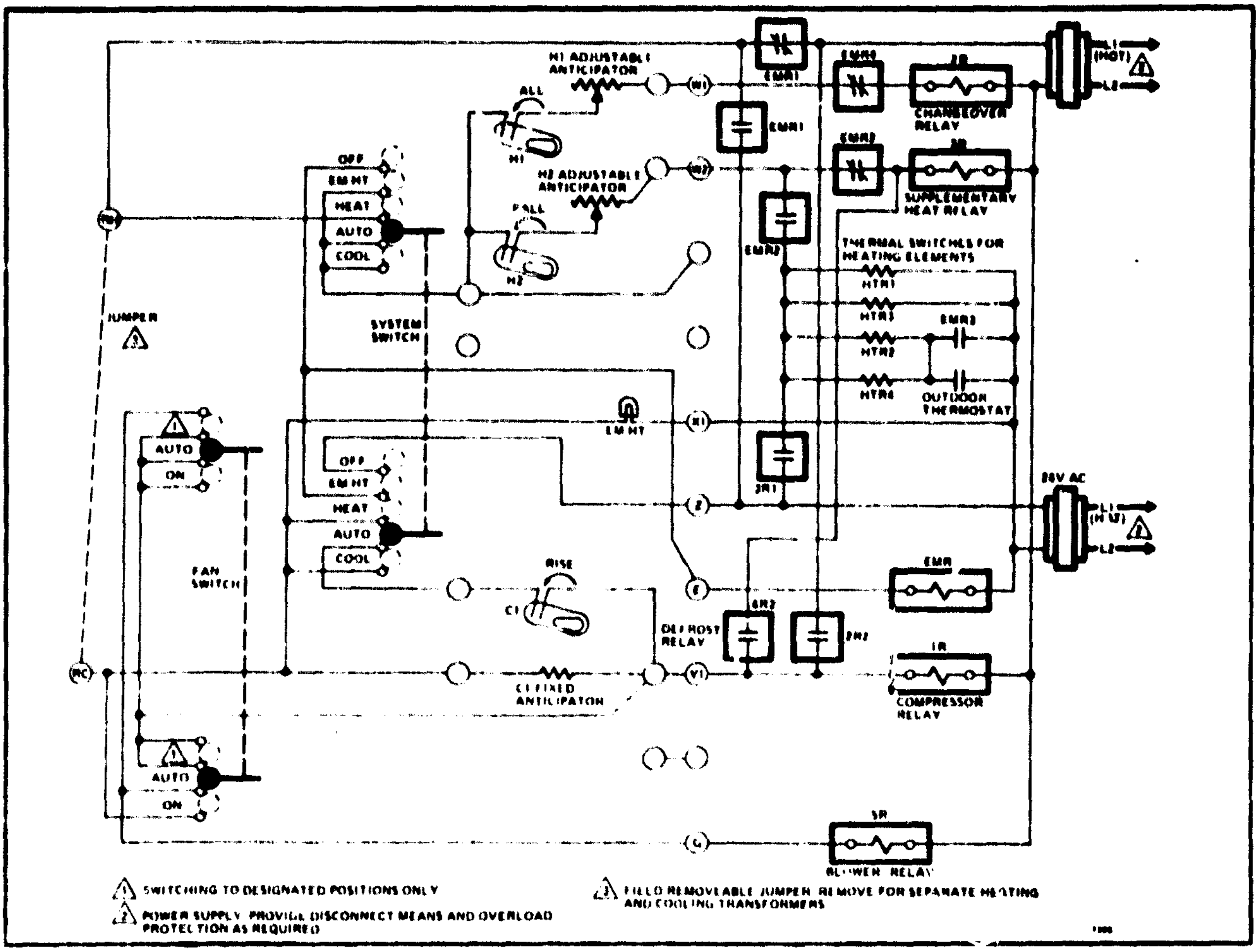


FIG. 25—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672F SUBBASE AND T872C THERMOSTAT. SUBBASE PROVIDES OFF-EM. HT.-HEAT-AUTO-COOL SYSTEM AND AUTO-ON FAN SWITCHING.

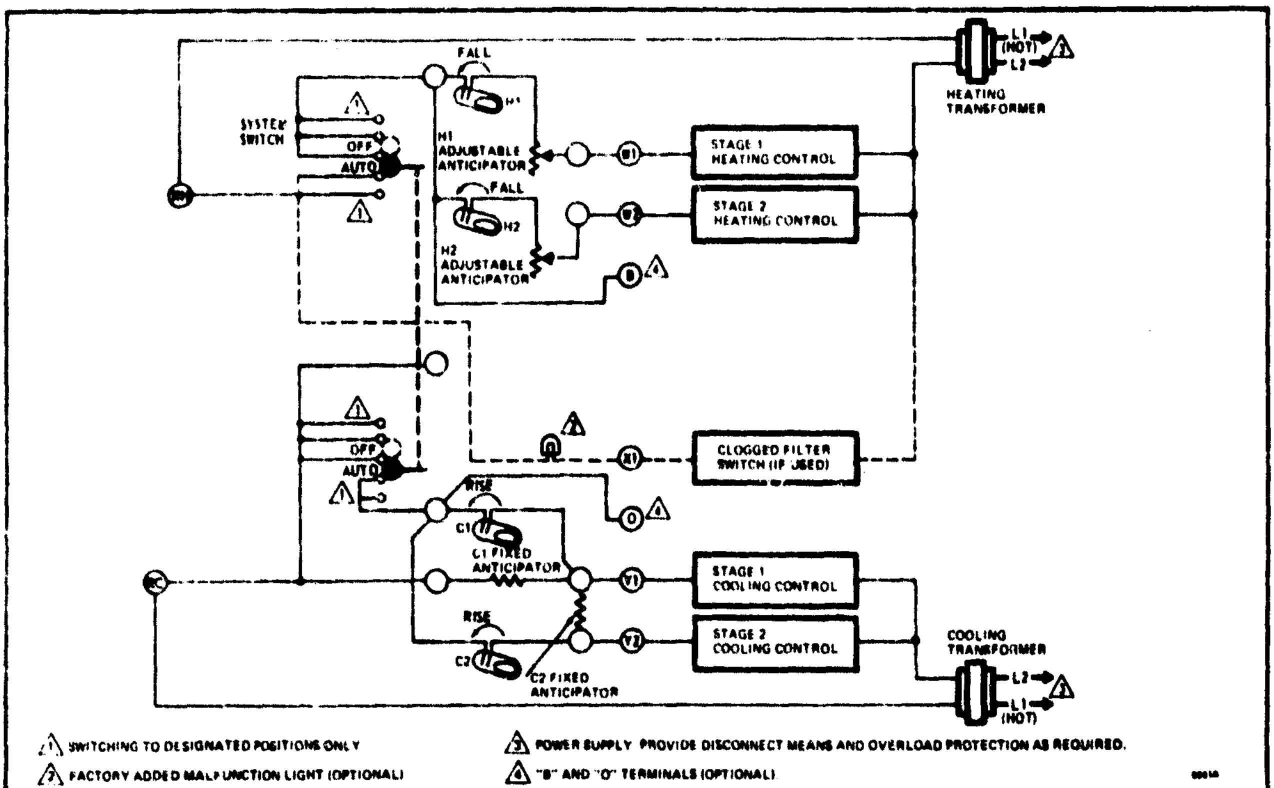


FIG. 26—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672G SUBBASE AND T872D THERMOSTAT. SUBBASE PROVIDES OFF-AUTO SYSTEM SWITCHING ONLY.

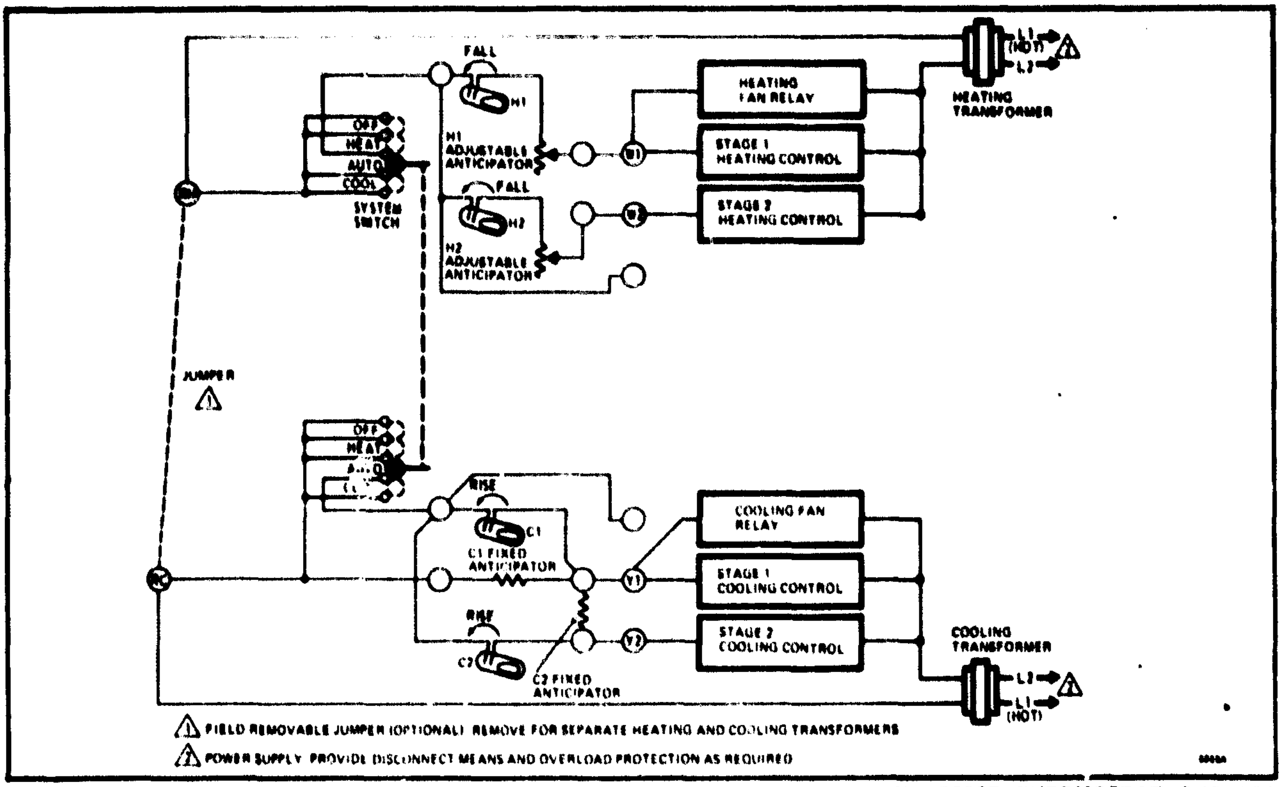


FIG. 27—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672K SUBBASE AND T872D THERMOSTAT. SUBBASE PROVIDES OFF-HEAT-AUTO-COOL SYSTEM SWITCHING ONLY.

STANDARD CIRCUITS WITH MANUAL HEAT-COOL CHANGEOVER

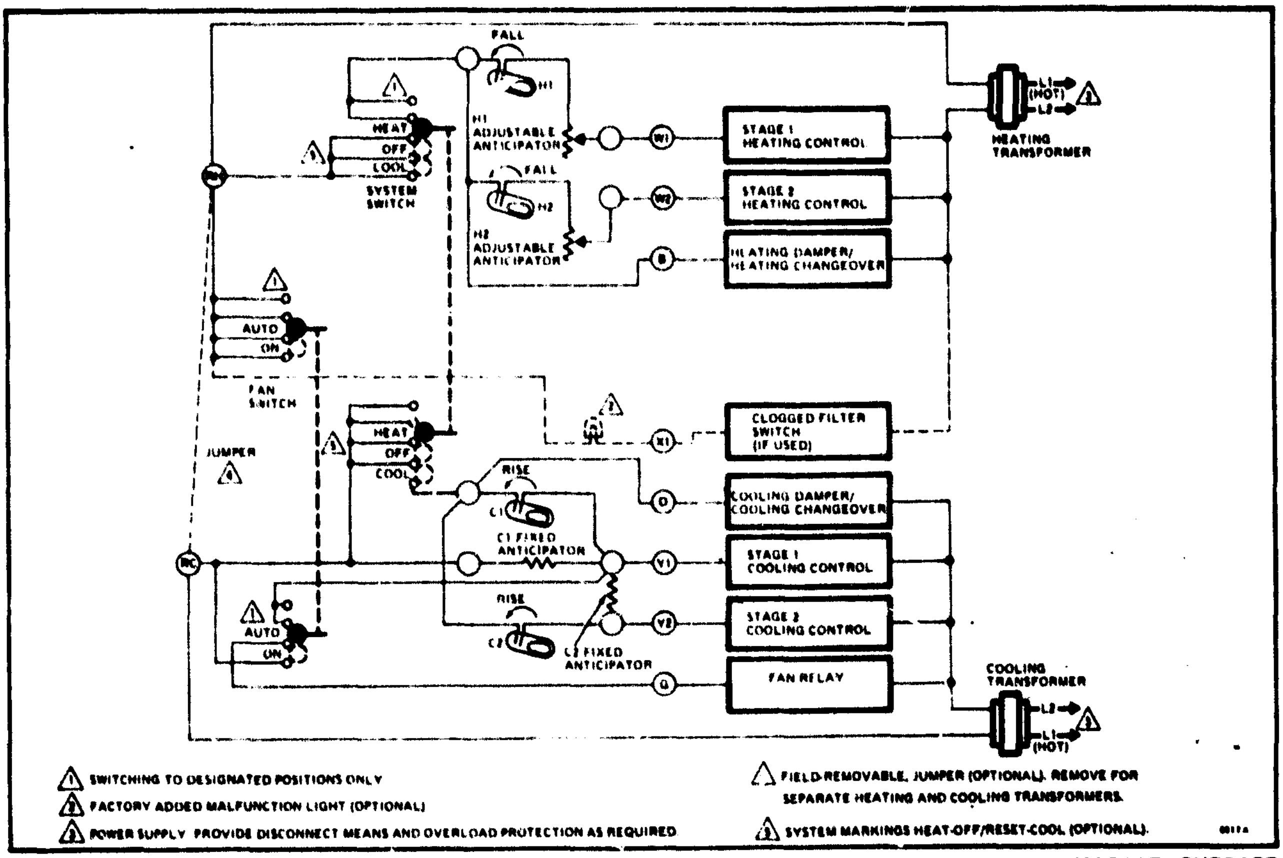


FIG. 28—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672B SUBBASE AND T872D THERMOSTAT. SUBBASE PROVIDES HEAT-OFF-COOL SYSTEM AND AUTO-ON FAN SWITCHING.

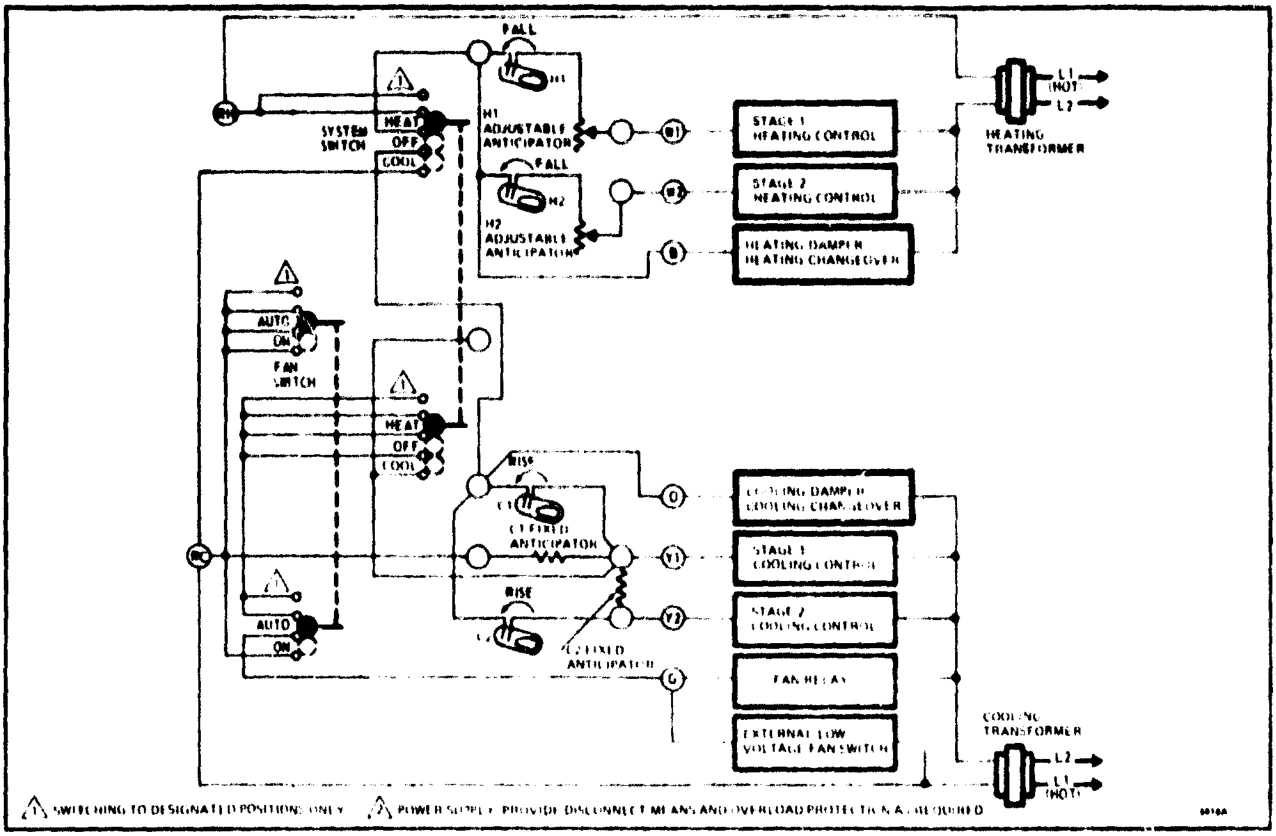


FIG. 29—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672B SUBBASE AND T872D THERMOSTAT. SUBBASE PROVIDES HEAT-OFF-COOL SYSTEM AND AUTO-ON FAN SWITCHING. G TERMINAL IS ISOLATED ON HEATING TO PROVIDE FAN RELAY OPERATION FROM EXTERNAL LOW VOLTAGE FAN SWITCH.

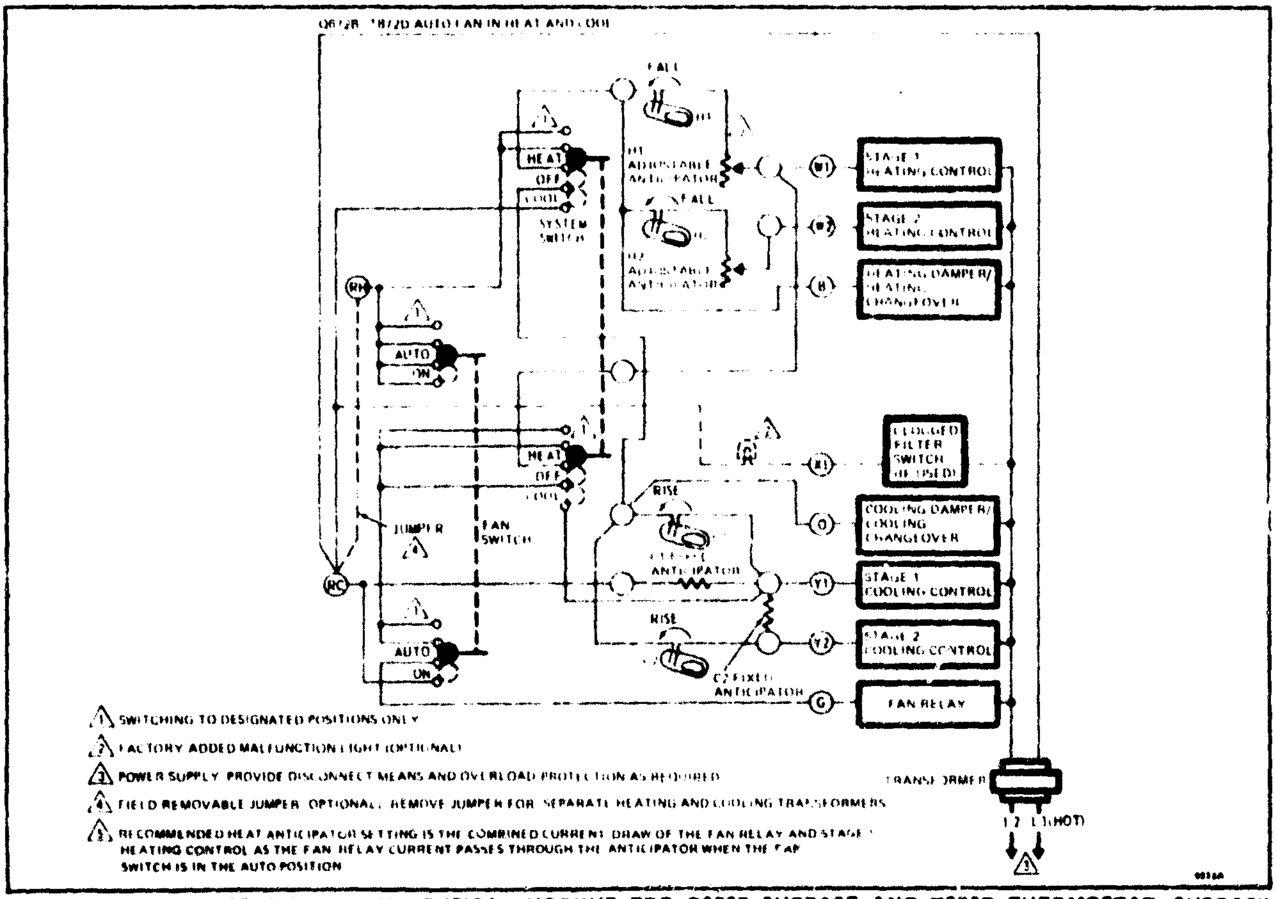


FIG. 30—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672B SUBBASE AND T872D THERMOSTAT. SUBBASE PROVIDES HEAT-OFF-COOL SYSTEM AND AUTO-ON FAN SWITCHING, AND AUTOMATIC FAN OPERATION IN HEATING AND COOLING FOR ELECTRIC FURNACE.

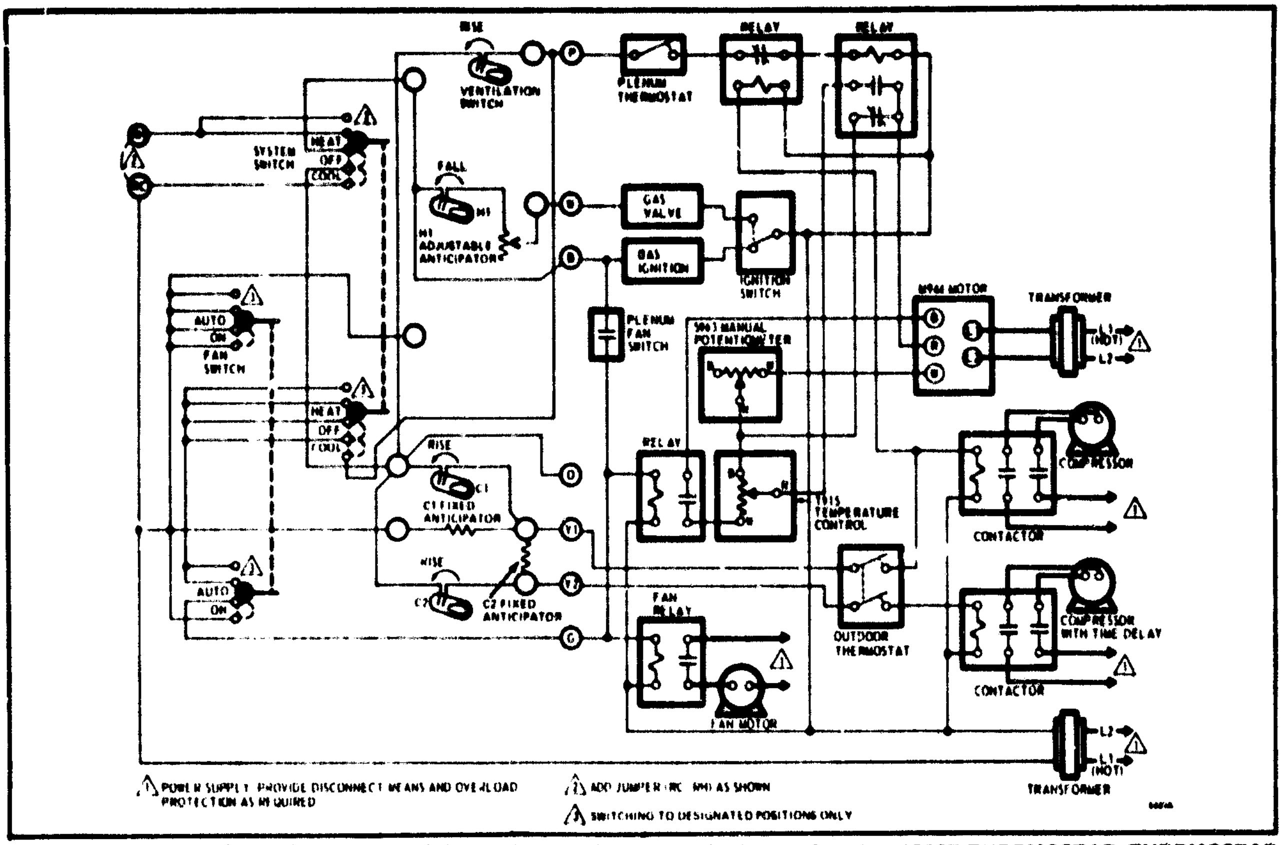


FIG. 31—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672B SUBBASE AND T872T THERMOSTAT. THERMOSTAT PROVIDES 1-STAGE HEATING, 1-STAGE VENTILATION, AND 2-STAGE COOLING. SUBBASE PROVIDES HEAT-OFF-COOL SYSTEM AND AUTO-ON FAN SWITCHING.

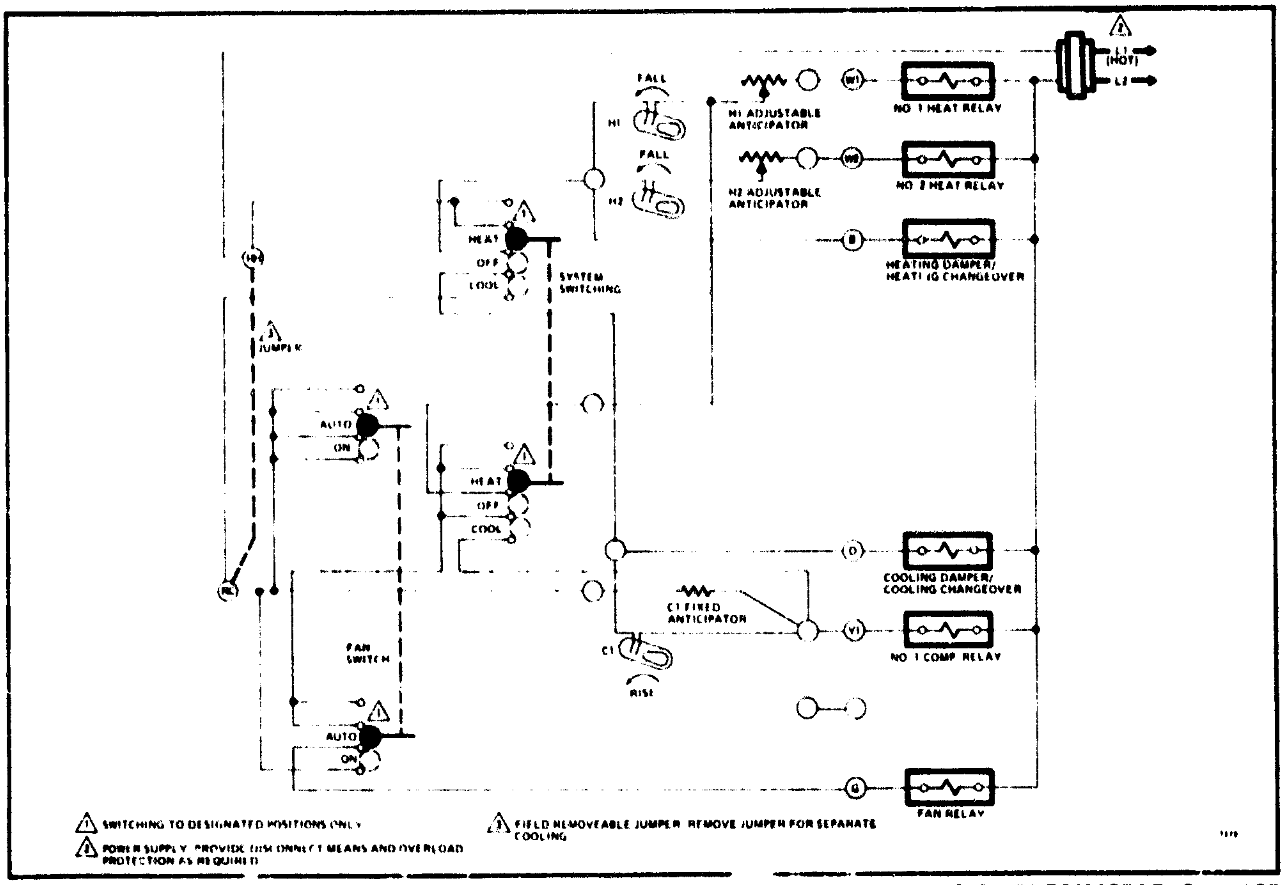


FIG. 32—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q67_6 SUBBASE AND T872C THERMOSTAT. SUBBASE PROVIDES HEAT-OFF-COOL SYSTEM AND AUTO-ON FAN SWITCHING.

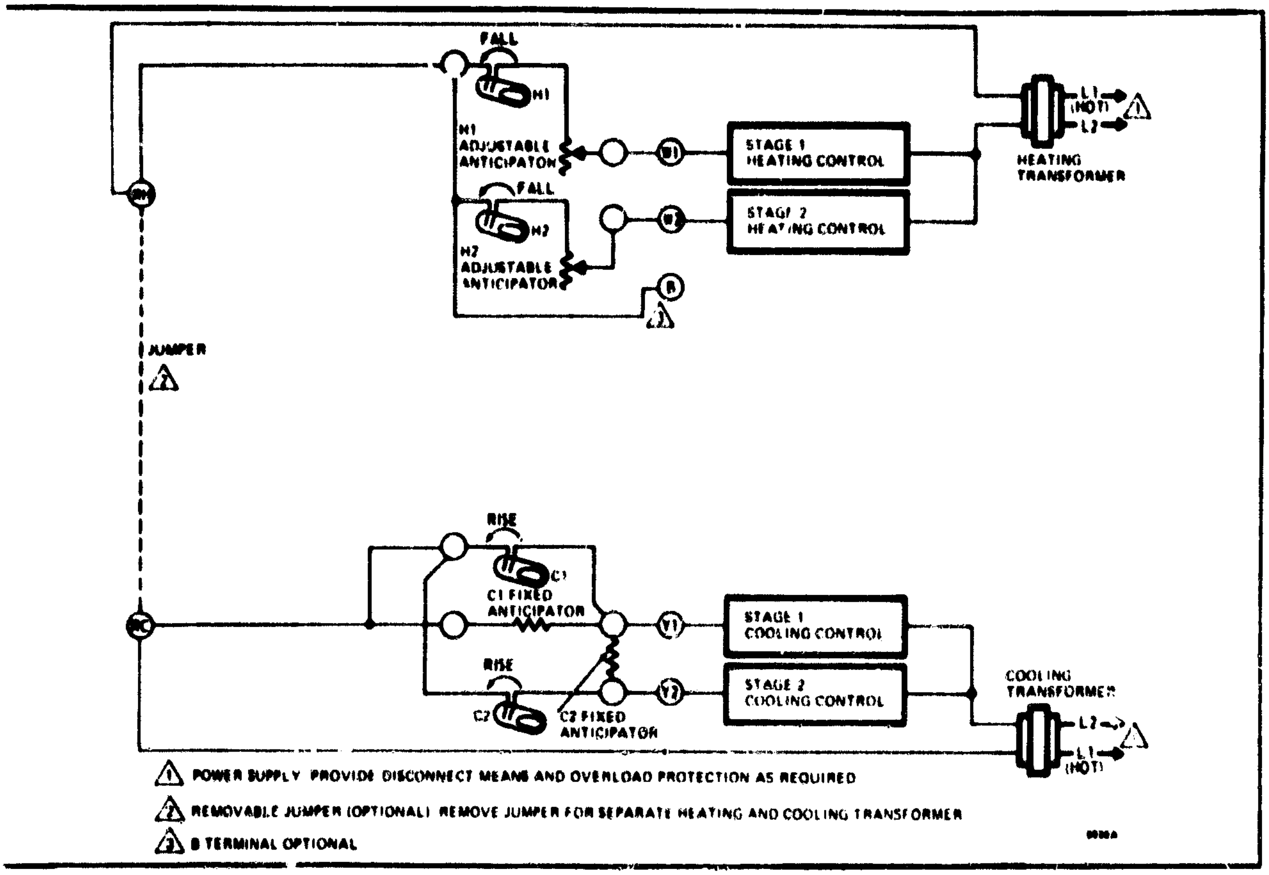


FIG. 33—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672D SUBBASE AND T872D THERMOSTAT. NO SUBBASE SWITCHING IS PROVIDED.

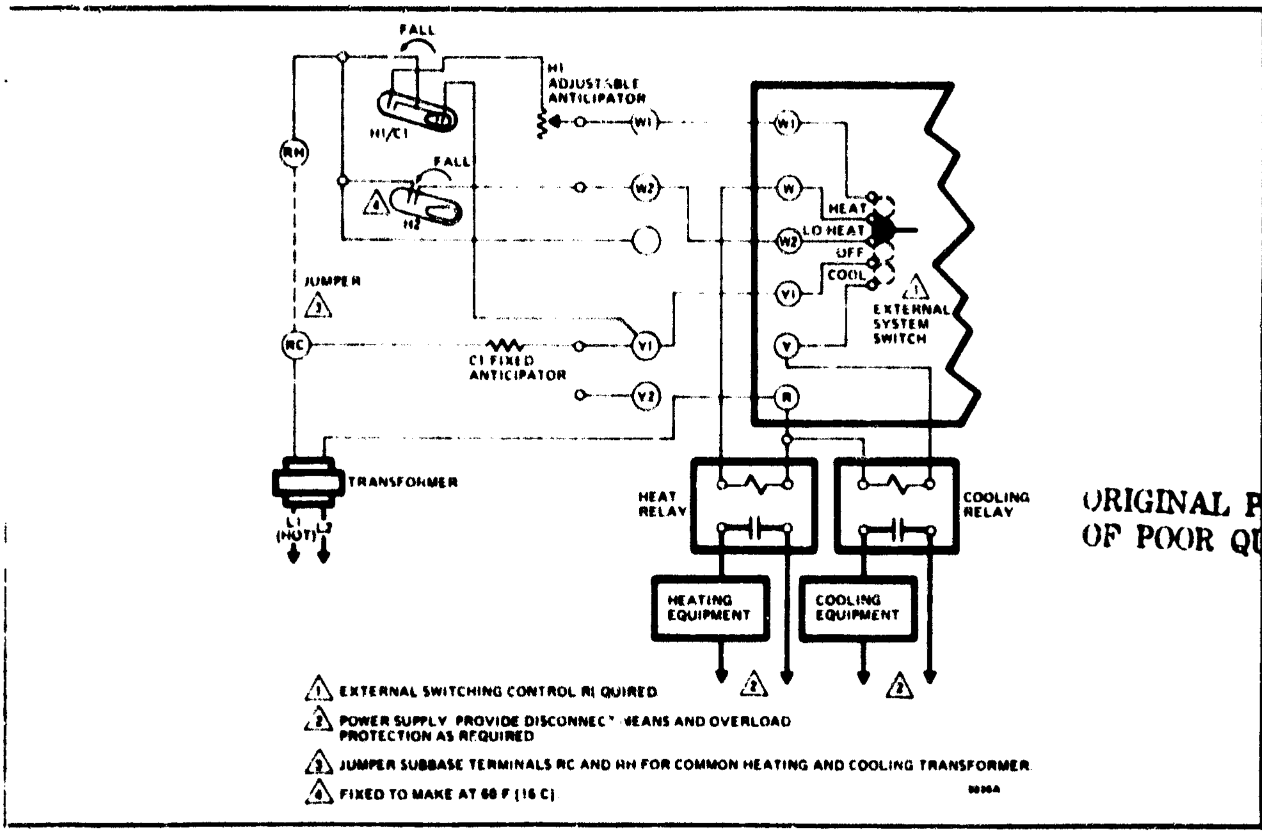


FIG. 34—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672D SUBBASE AND T872M THERMOSTAT. SYSTEM SWITCHING TO BE PROVIDED EXTERNALLY, SECOND-STAGE HEAT IS FIXED TO MAKE AT 60 F (16 C).

HEAT PUMP CIRCUITS WITH AUTOMATIC CHANGEOVER ON COOLING

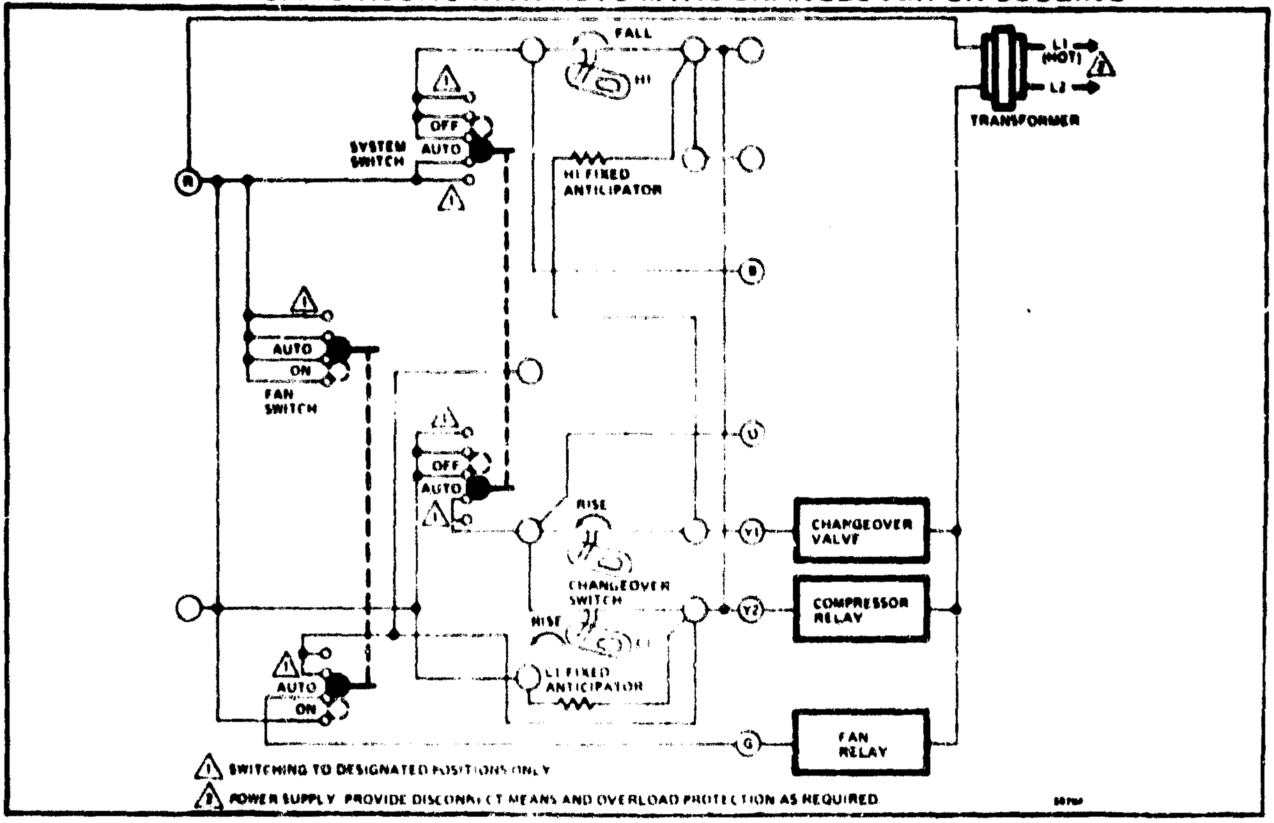


FIG. 35—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672C/T872H IN HEAT PUMP APPLICATION. THERMOSTAT PROVIDES 1-STAGE HEATING AND 1-STAGE COOLING; CHANGEOVER VALVE OPERATES WITH COOLING. SUBBASE PROVIDES OFF-AUTO SYSTEM AND AUTO-ON FAN SWITCHING.

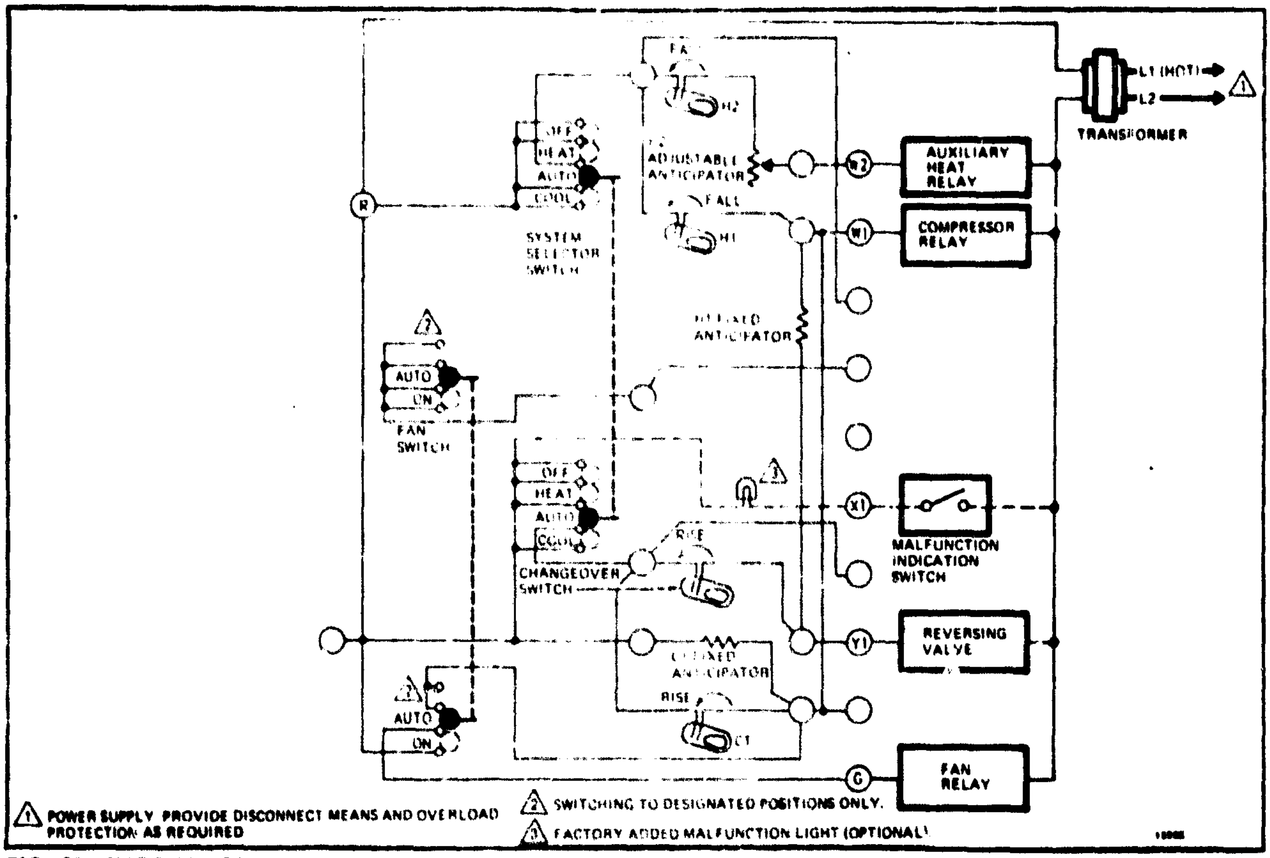


FIG. 36—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672E/T872G IN HEAT PUMP APPLICATION. THERMOSTAT PROVIDES 2-STAGE HEATING AND 1-STAGE COOLING; CHANGEOVER VALVE OPERATES WITH COOLING. SUBBASE PROVIDES OFF-HEAT-AUTO-COOL SYSTEM AND AUTO-ON FAN SWITCHING.

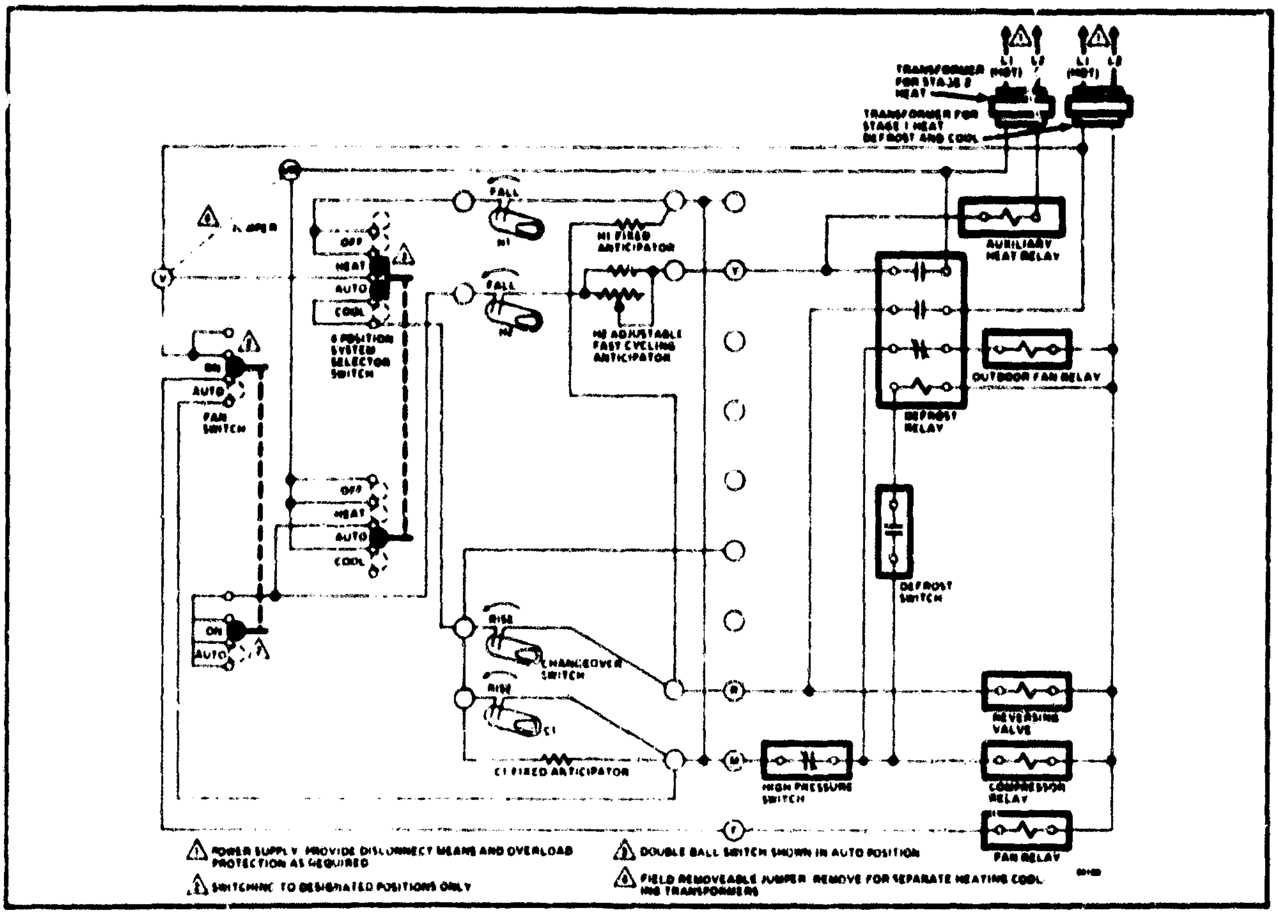


FIG. 37—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672E/T872G IN HEAT PUMP APPLICATION. THERMOSTAT PROVIDES 2-STAGE HEATING (SECOND-STAGE HEAT IS FAST CYCLING) AND 1-STAGE COOLING; CHANGEOVER VALVE OPERATES WITH COOLING. SUBBASE PROVIDES OFF-EM.HT.-HEAT-AUTO-COOL SYSTEM AND AUTO-ON FAN SWITCHING.

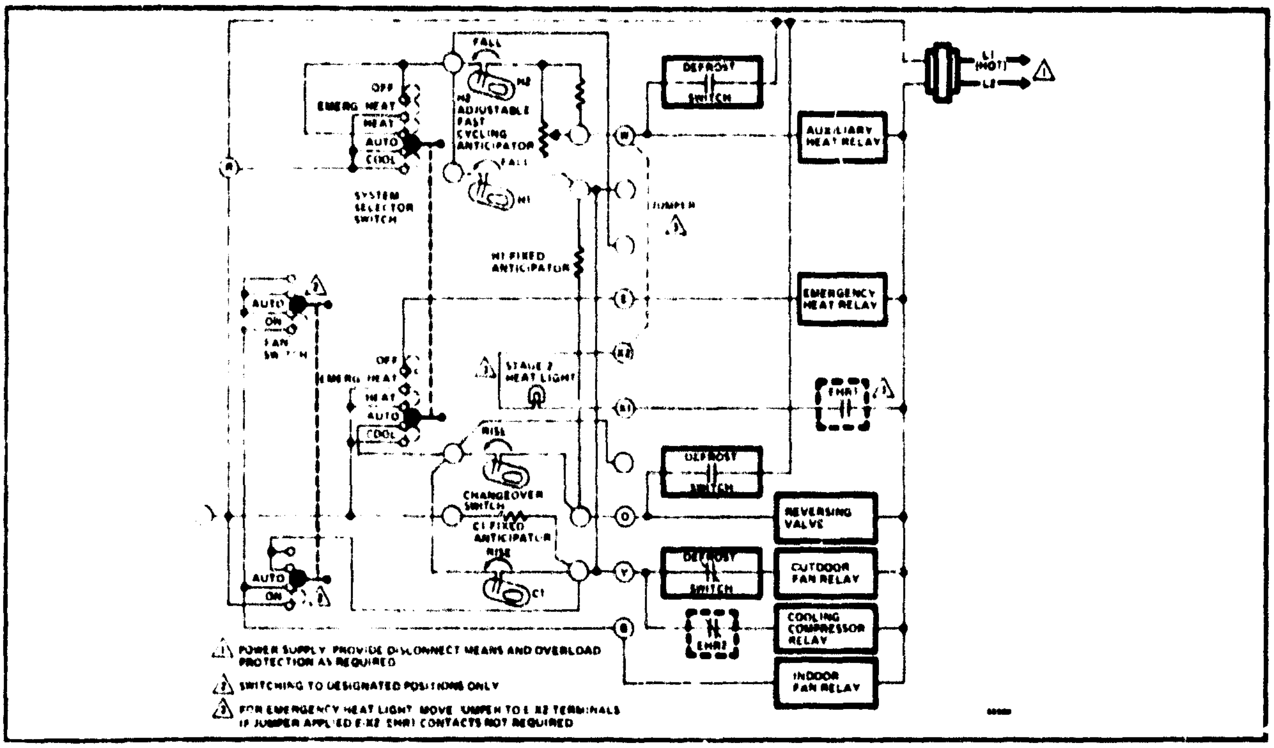


FIG. 38—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672F/T872G IN HEAT PUMP APPLICATION. THERMOSTAT PROVIDES 2-STAGE HEATING (SECOND-STAGE HEAT IS FAST CYCLING) AND 1-STAGE COOLING; CHANGEOVER VALVE OPERATES WITH COOLING. SUBBASE PROVIDES OFF-EM.HT.-HEAT-AUTO-COOL SYSTEM AND AUTO-ON FAN SWITCHING.

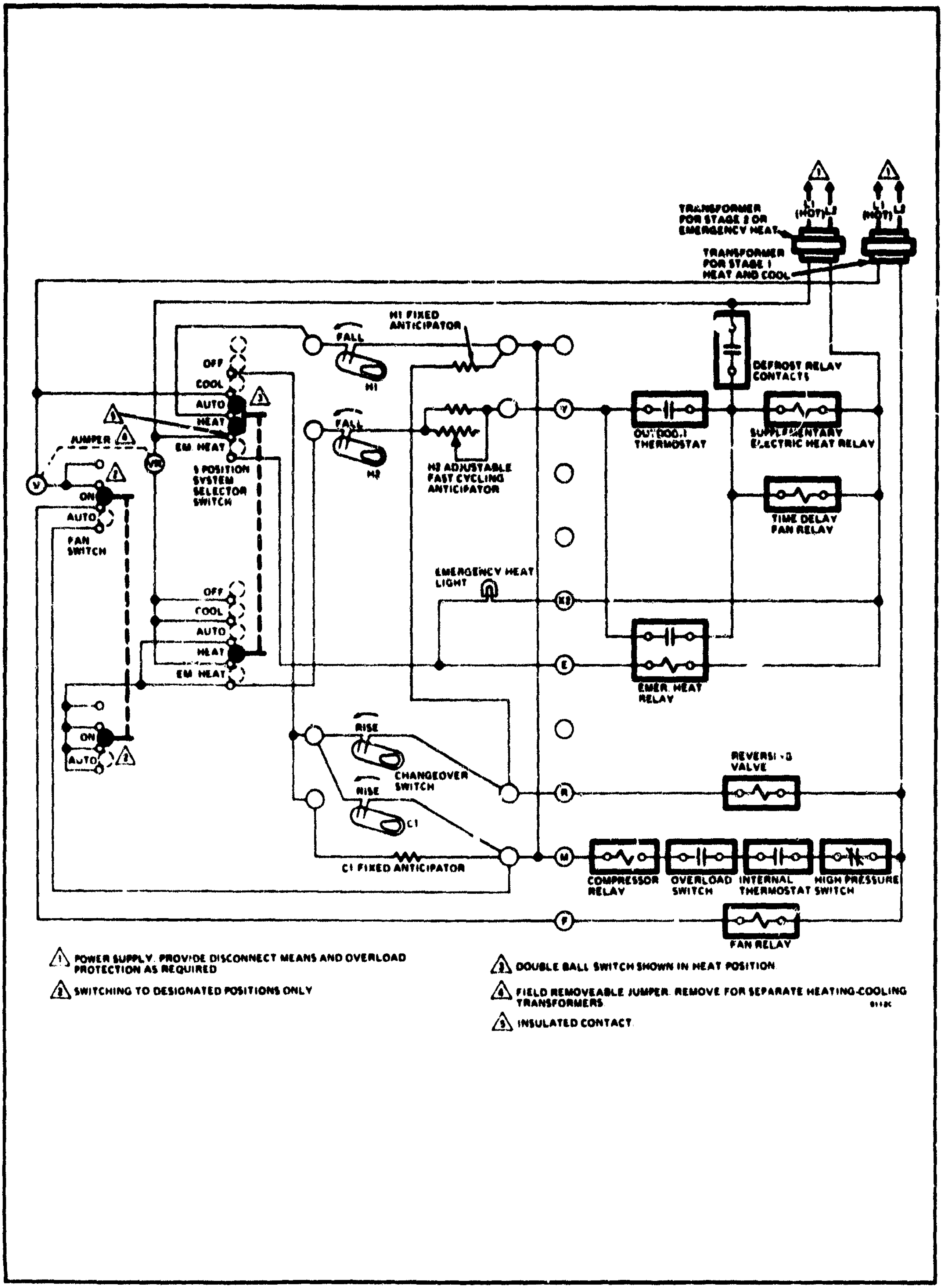
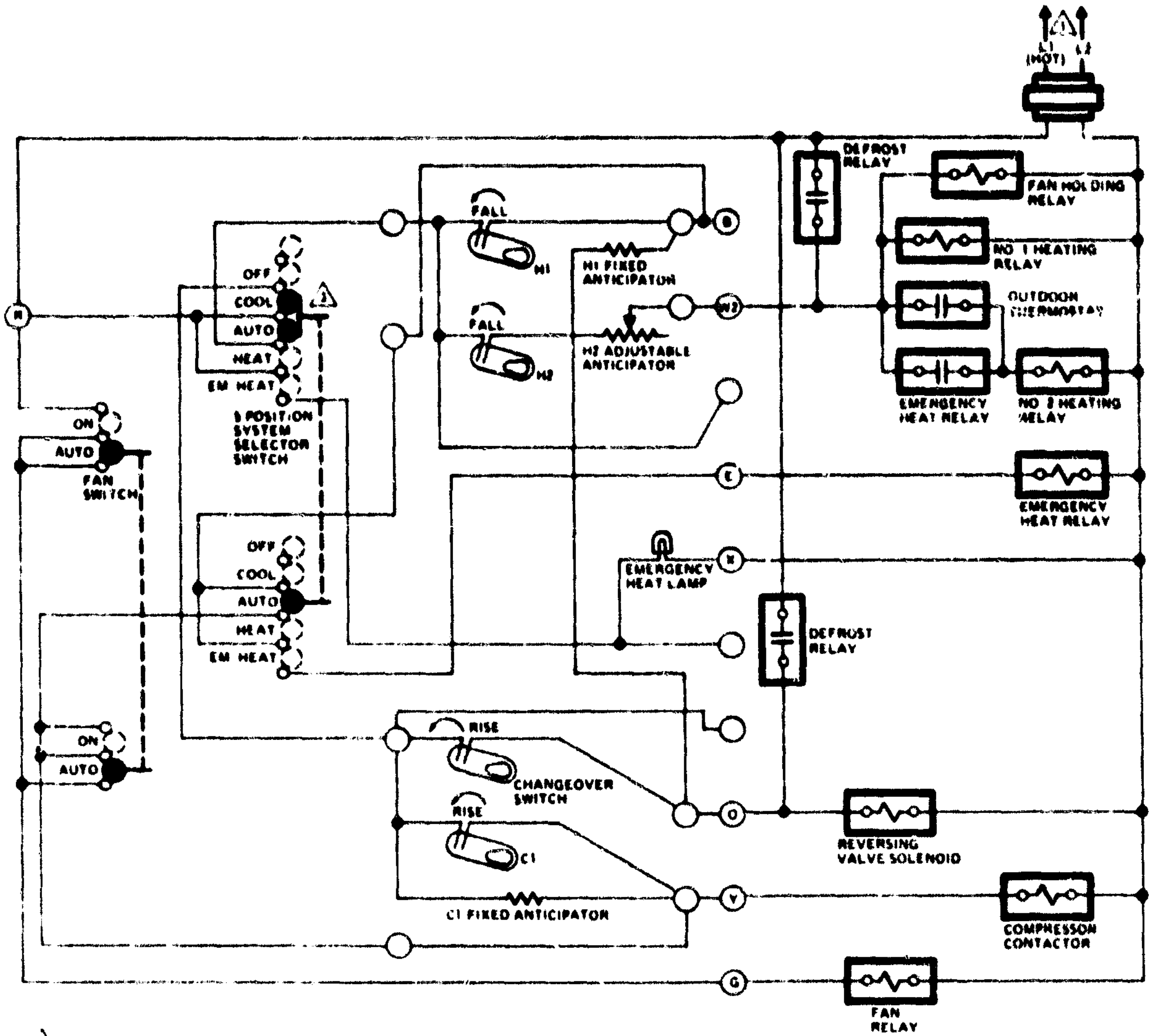


FIG. 39—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672F/T872G IN HEAT PUMP APPLICATION. THERMOSTAT PROVIDES 2-STAGE HEATING (SECOND-STAGE HEAT IS FAST CYCLING) AND 1-STAGE COOLING; CHANGEOVER VALVE OPERATES WITH COOLING. SUBBASE PROVIDES OFF-COOL-AUTO-HEAT-EM. HT. SYSTEM AND AUTO-ON FAN SWITCHING.



1 PROVIDE DISCONNECT MEANS AND OVERLOAD PROTECTION AS REQUIRED.

2 FAN HOLDING RELAY MUST BE USED TO ENERGIZE FAN IN EMERGENCY HEAT MODE.

3 DOUBLE BALL SWITCH SHOWN IN AUTO POSITION

FIG. 45—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672F/T872G IN HEAT PUMP APPLICATION. THERMOSTAT PROVIDES 2-STAGE HEATING AND 1-STAGE COOLING; CHANGEOVER VALVE OPERATES WITH COOLING. SUBBASE PROVIDES OFF-COOL-AUTO-HEAT-EM.HT. SYSTEM AND AUTO-ON FAN SWITCHING.

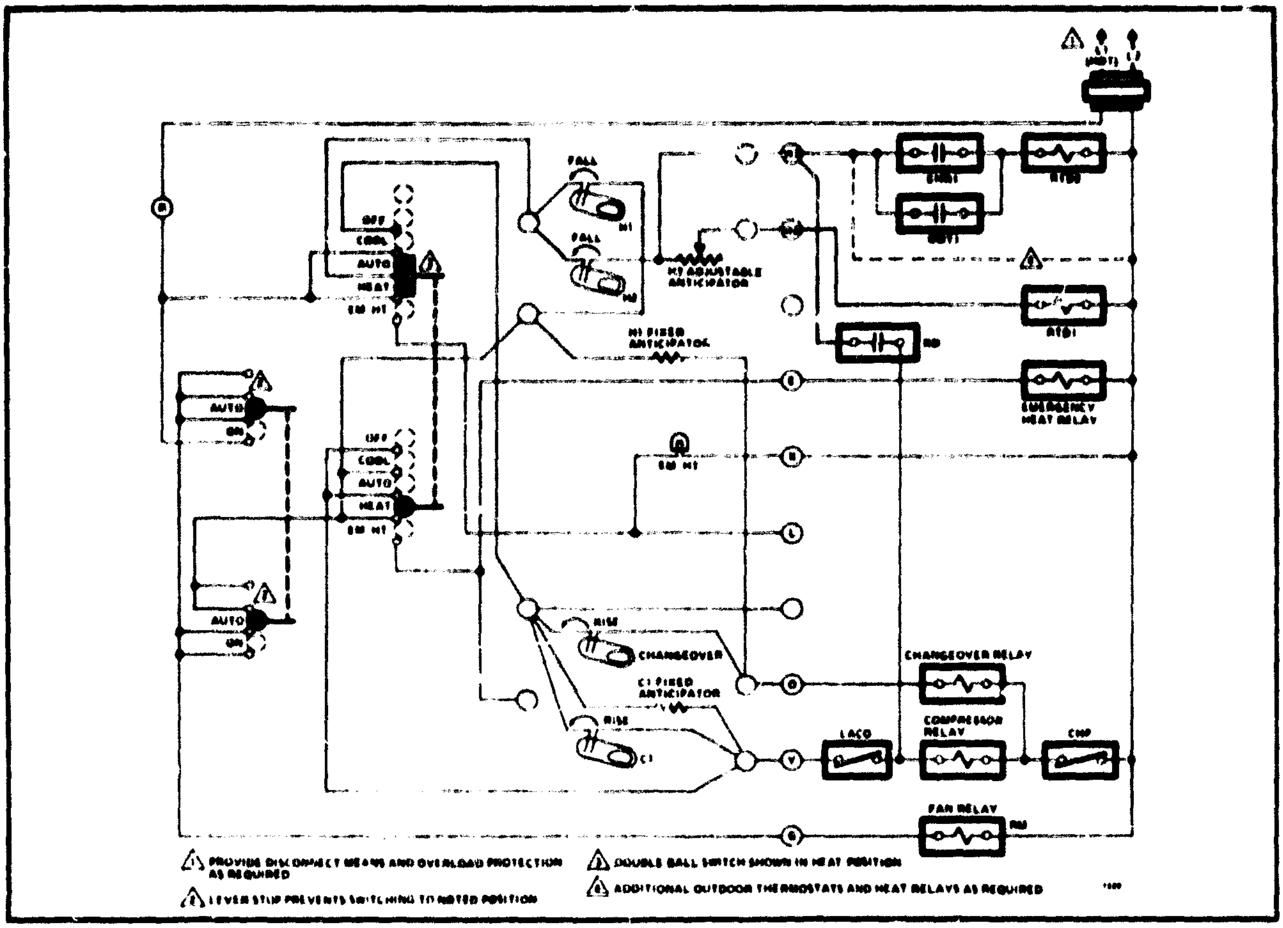


FIG. 41—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672F/T872G IN HEAT PUMP APPLICATION. THERMOSTAT PROVIDES 2-STAGE HEATING AND 1-STAGE COOLING; CHANGEOVER VALVE OPERATES WITH COOLING. SUBBASE PROVIDES OFF-COOL-AUTO-HEAT-EM.HT. SYSTEM AND AUTO-ON FAN SWITCHING.

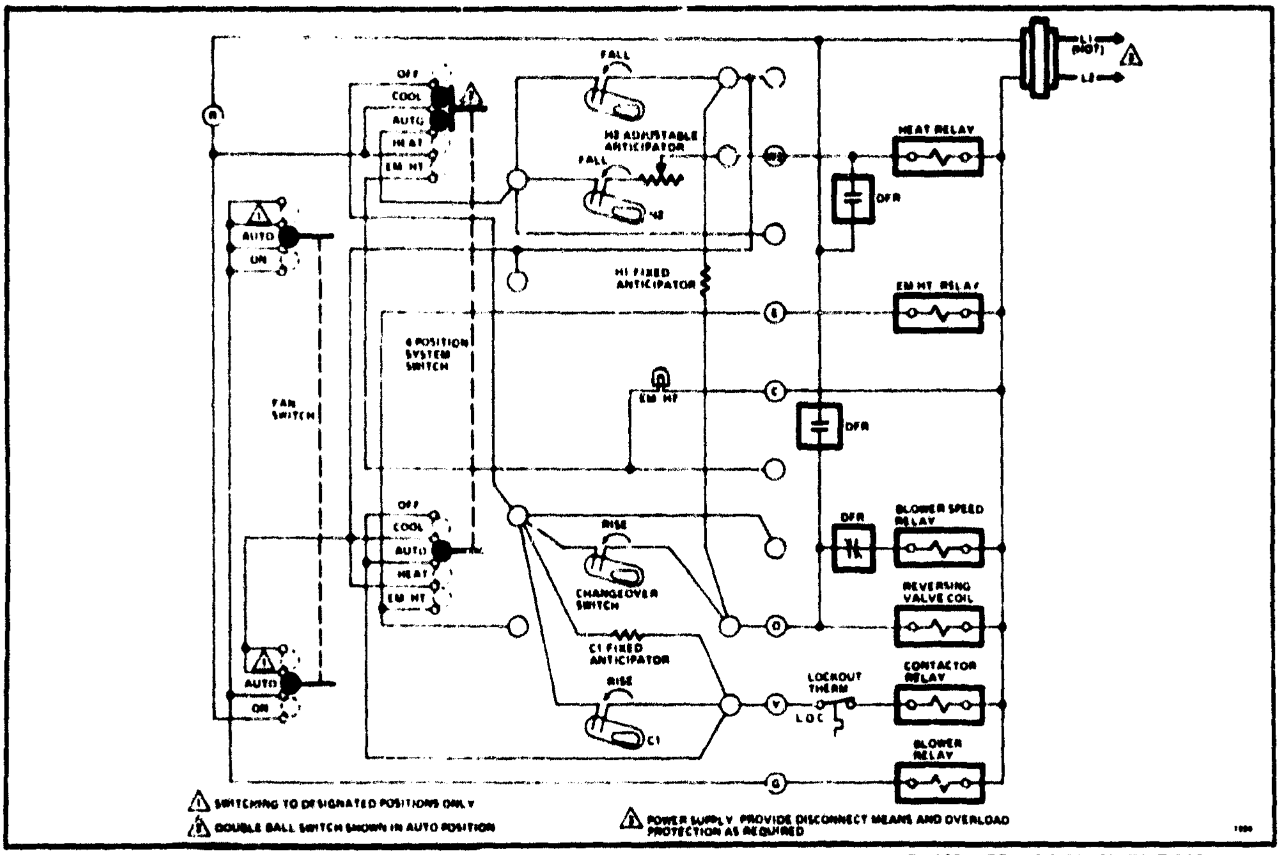


FIG. 42—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672F/T872G IN HEAT PUMP APPLICATION. THERMOSTAT PROVIDES 2-STAGE HEATING AND 1-STAGE COOLING; CHANGEOVER VALVE OPERATES WITH COOLING. SUBBASE PROVIDES OFF-COOL-AUTO-HEAT-EM.HT. SYSTEM AND AUTO-ON FAN SWITCHING.

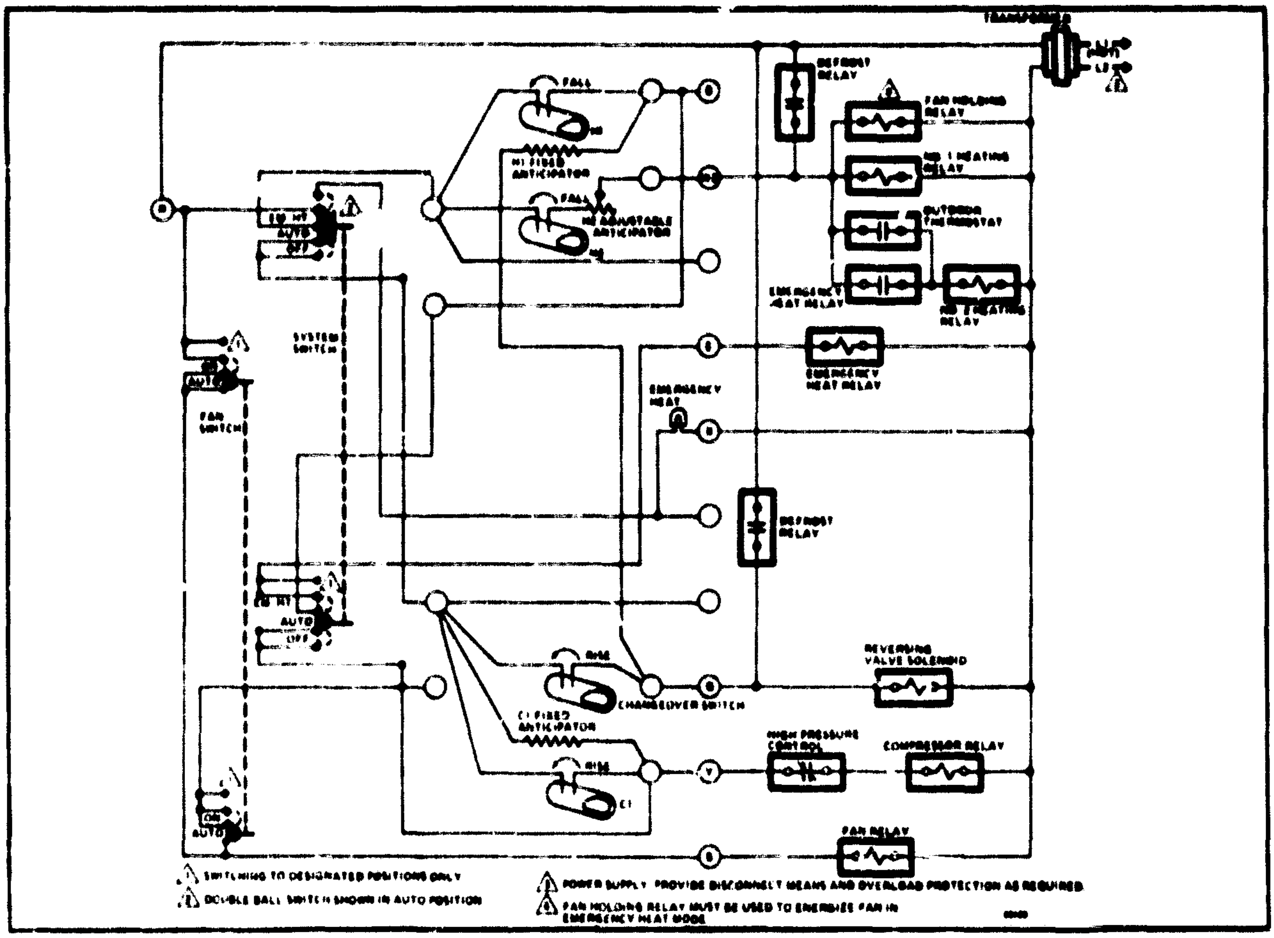


FIG. 43—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672J/T872G IN HEAT PUMP APPLICATION. THERMOSTAT PROVIDES 2-STAGE HEATING AND 1-STAGE COOLING; CHANGEOVER VALVE OPERATES WITH COOLING. SUBBASE PROVIDES OFF-COOL-AUTO-HEAT SYSTEM AND AUTO-ON FAN SWITCHING.

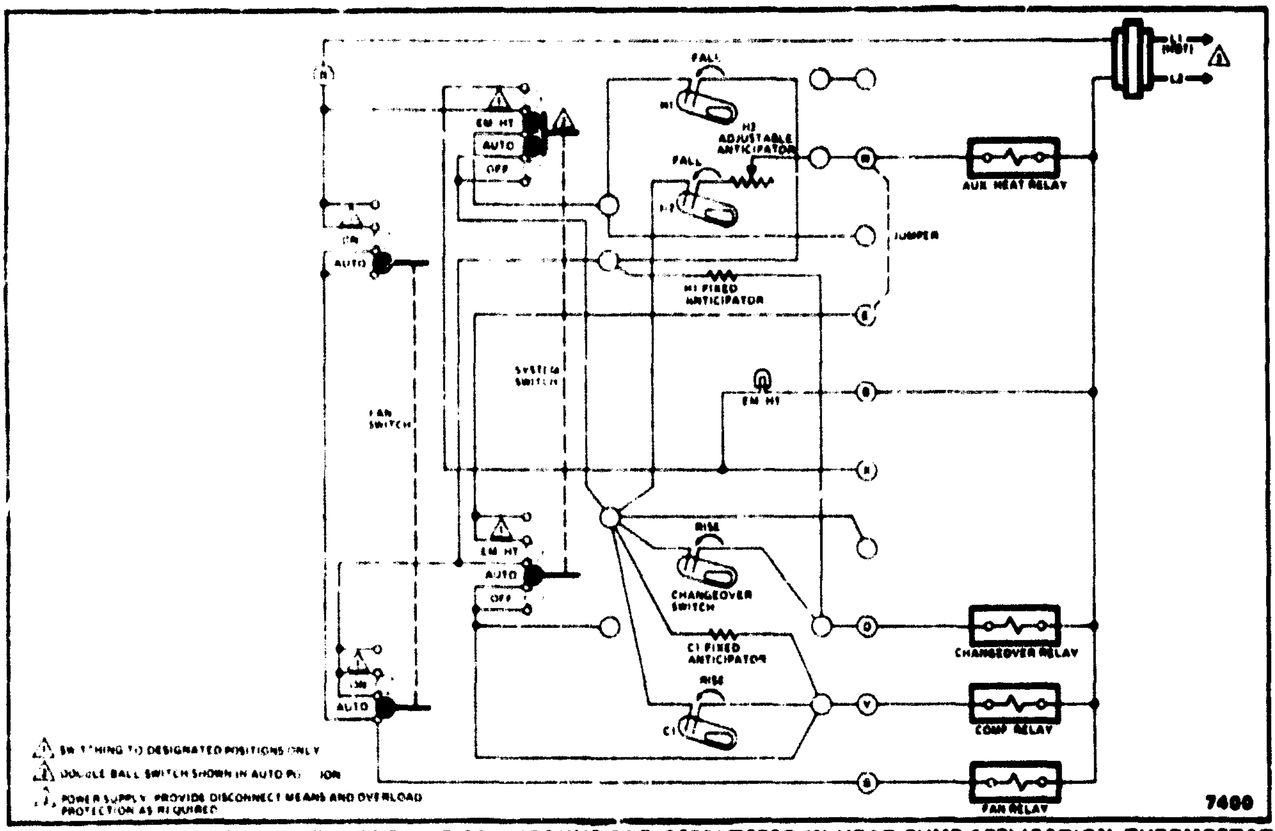


FIG. 44—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672J/T872G IN HEAT PUMP APPLICATION. THERMOSTAT PROVIDES 2-STAGE HEATING AND 1-STAGE COOLING; CHANGEOVER VALVE OPERATES WITH COOLING. SUBBASE PROVIDES EM.HT-AUTO-OFF SYSTEM AND AUTO-ON FAN SWITCHING.

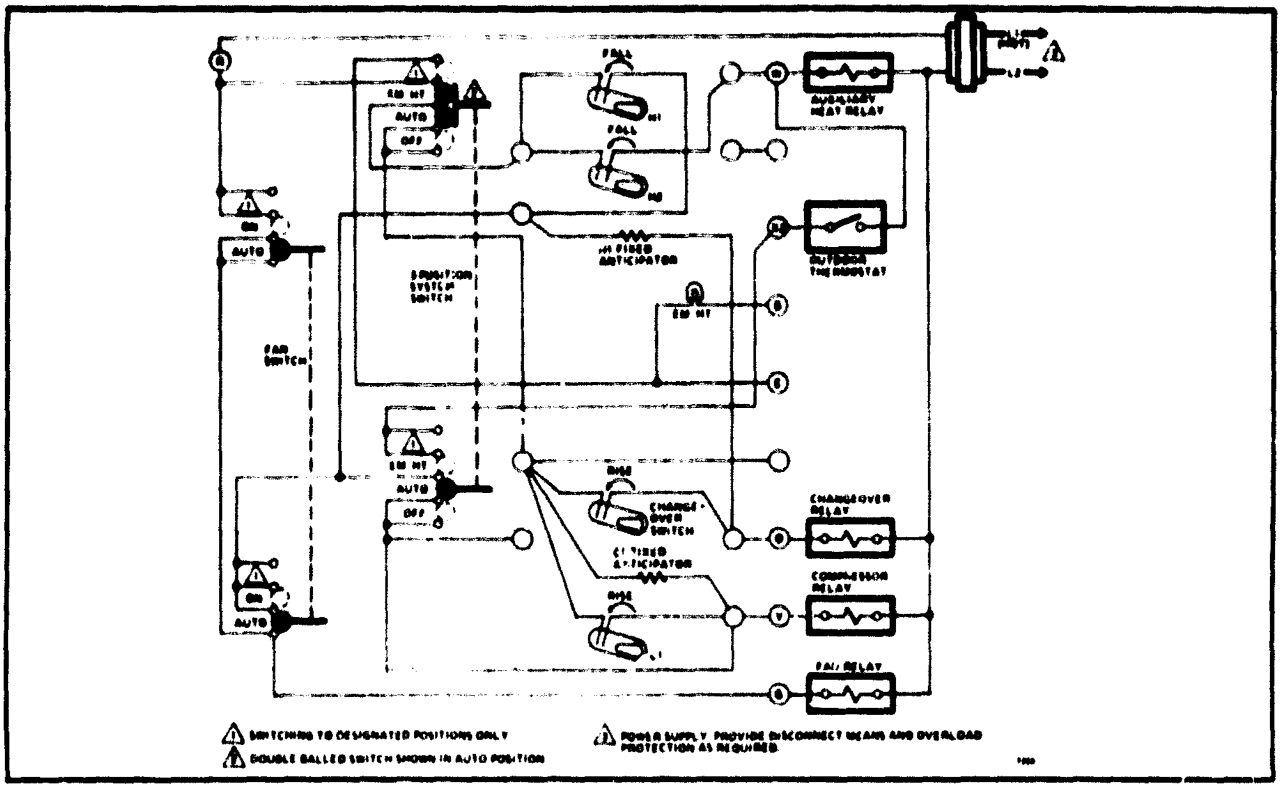


FIG. 48—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672J/T872G IN HEAT PUMP APPLICATION. THERMOSTAT PROVIDES 2-STAGE HEATING AND 1-STAGE COOLING; CHANGEOVER VALVE OPERATES WITH COOLING. SUBBASE PROVIDES EM.HT.-AUTO-OFF SYSTEM AND AUTO-ON FAN SWITCHING.

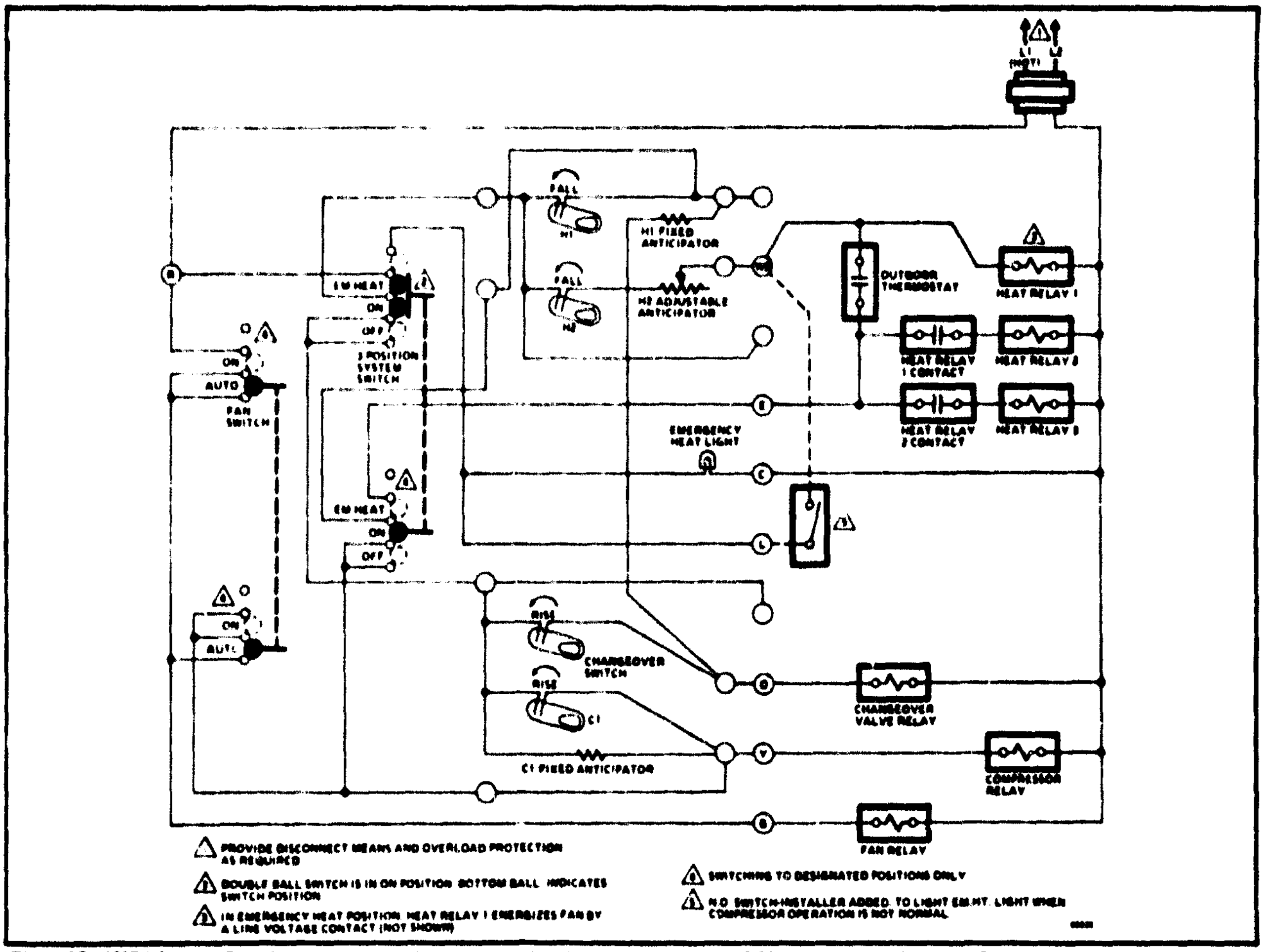


FIG. 49—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672J/T872G IN HEAT PUMP APPLICATION. THERMOSTAT PROVIDES 2-STAGE HEATING AND 1-STAGE COOLING; CHANGEOVER VALVE OPERATES WITH COOLING. SUBBASE PROVIDES EM.HT.-ON-OFF SYSTEM AND AUTO-ON FAN SWITCHING.

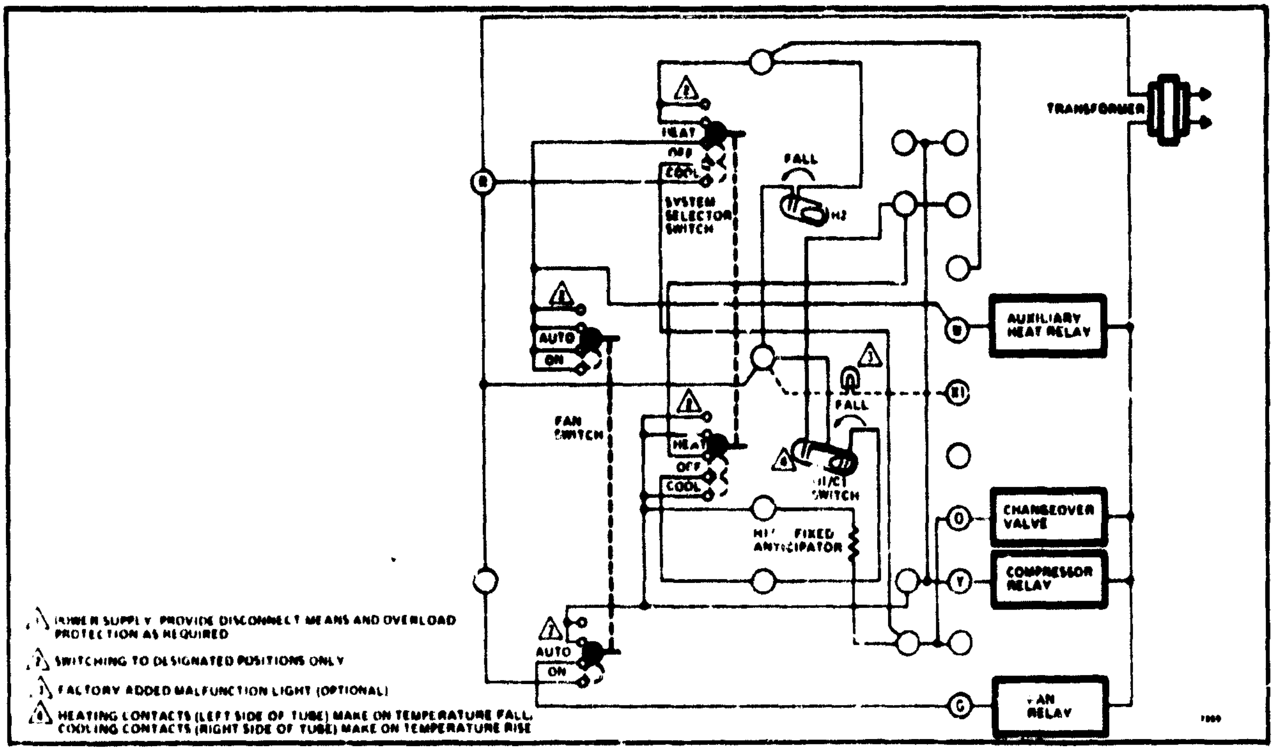


FIG. 47—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672B/T872R IN HEAT PUMP APPLICATION. THERMOSTAT PROVIDES 2-STAGE HEATING AND 1-STAGE COOLING; MANUAL CHANGEOVER OPERATES ON COOLING. SUBBASE PROVIDES HEAT-OFF-COOL SYSTEM AND AUTO-ON FAN SWITCHING.

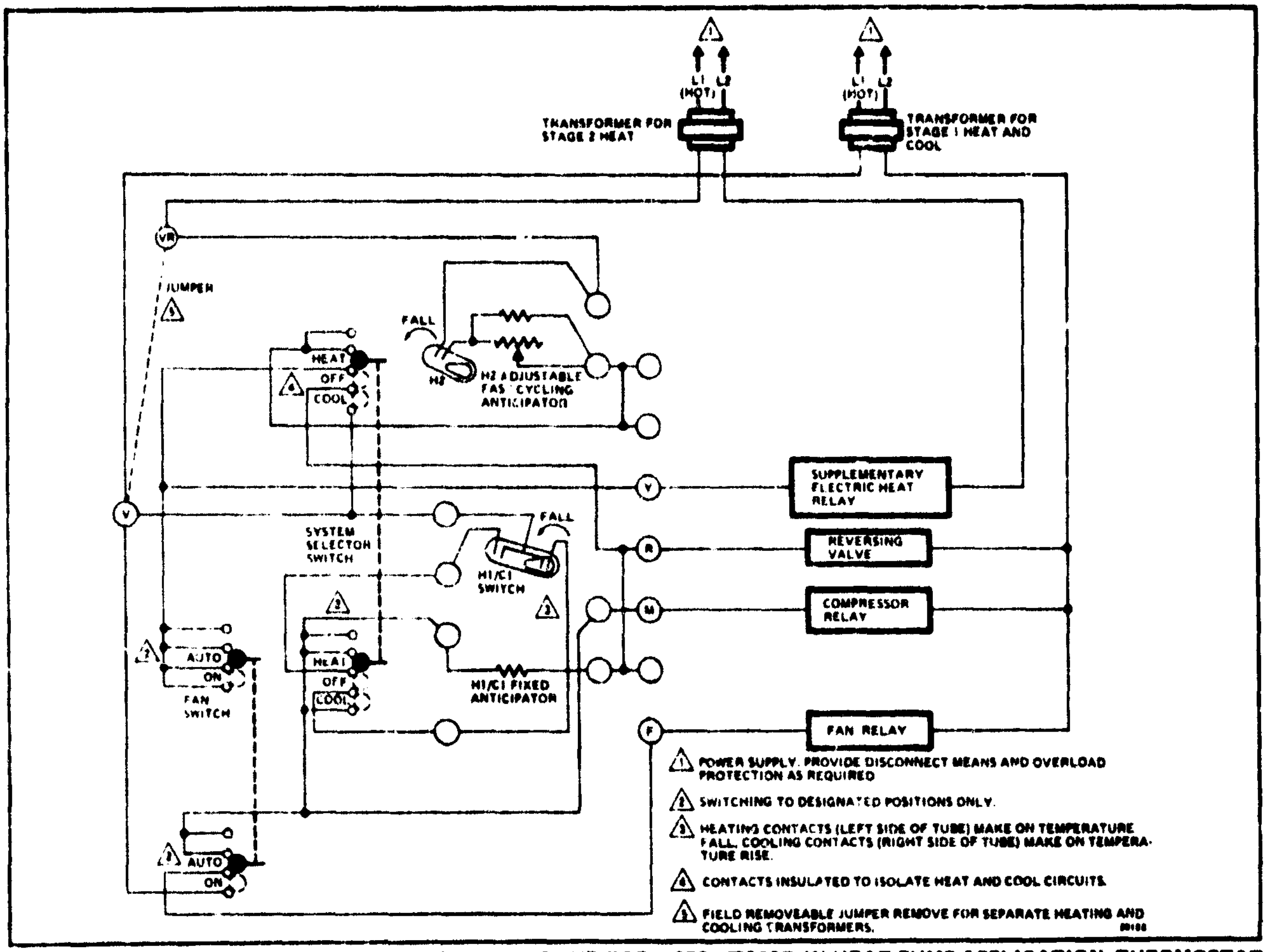


FIG. 48—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672B/T872R IN HEAT PUMP APPLICATION. THERMOSTAT PROVIDES 2-STAGE HEATING AND 1-STAGE COOLING; MANUAL CHANGEOVER OPERATES ON COOLING. FAST CYCLING STAGE 2 HEAT HAS ISOLATED CIRCUIT AND SEPARATE TRANSFORMER. SUBBASE PROVIDES HEAT-OFF-COOL SYSTEM AND AUTO-ON FAN SWITCHING.

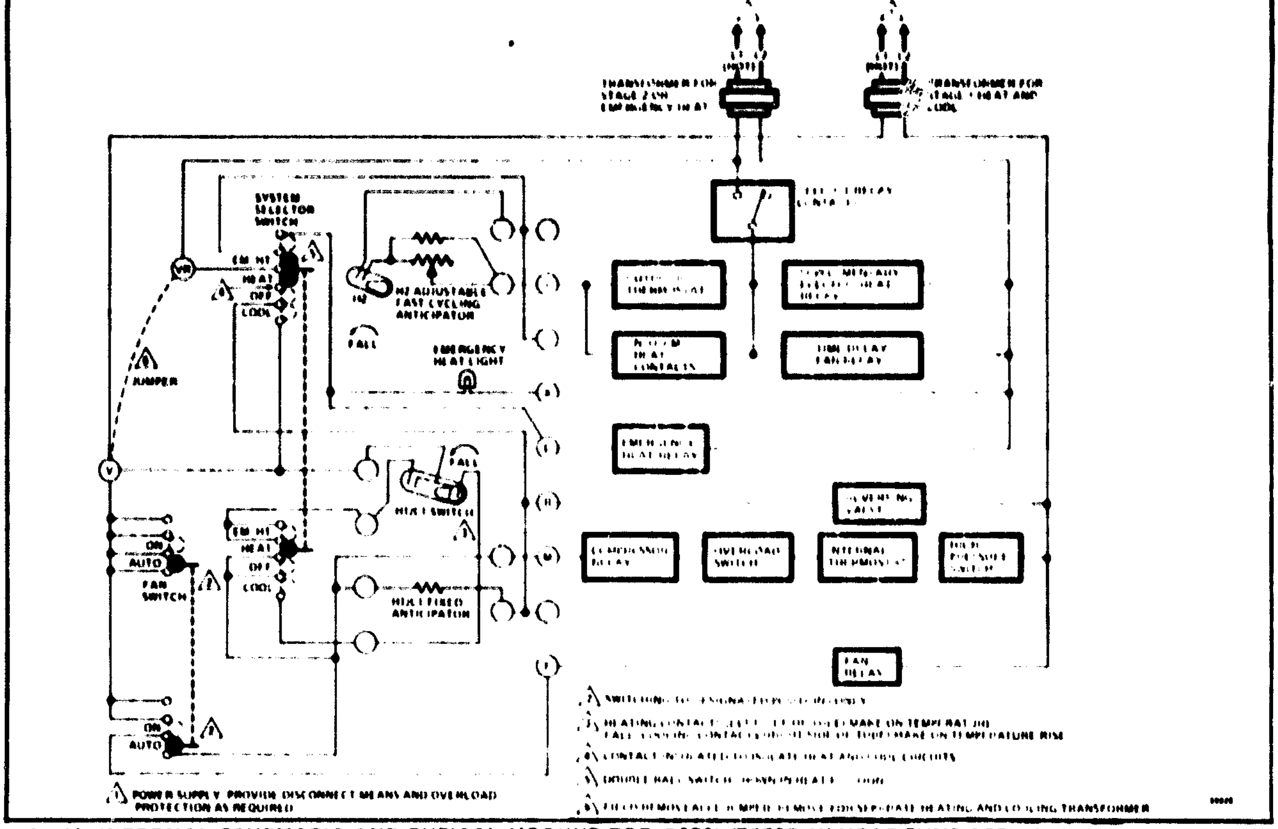


FIG. 49—INTERNAL SCHEMATIC AND TYPICAL HOOKUP FOR Q672L/T872R IN HEAT PUMP APPLICATION. THERMOSTAT PROVIDES 2-STAGE HEATING AND 1-STAGE COOLING; MANUAL CHANGEOVER OPERATES ON COOLING. FAST CYCLING STAGE 2 HEAT HAS ISOLATED CIRCUIT AND SEPARATE TRANSFORMER. EMERGENCY HEAT RELAY AND LIGHT ARE ENERGIZED IN EM.HT. SWITCH POSITION. SUBBASE PROVIDES EM.HT.-HEAT-OFF-COOL SYSTEM AND AUTO-ON FAN SWITCHING.

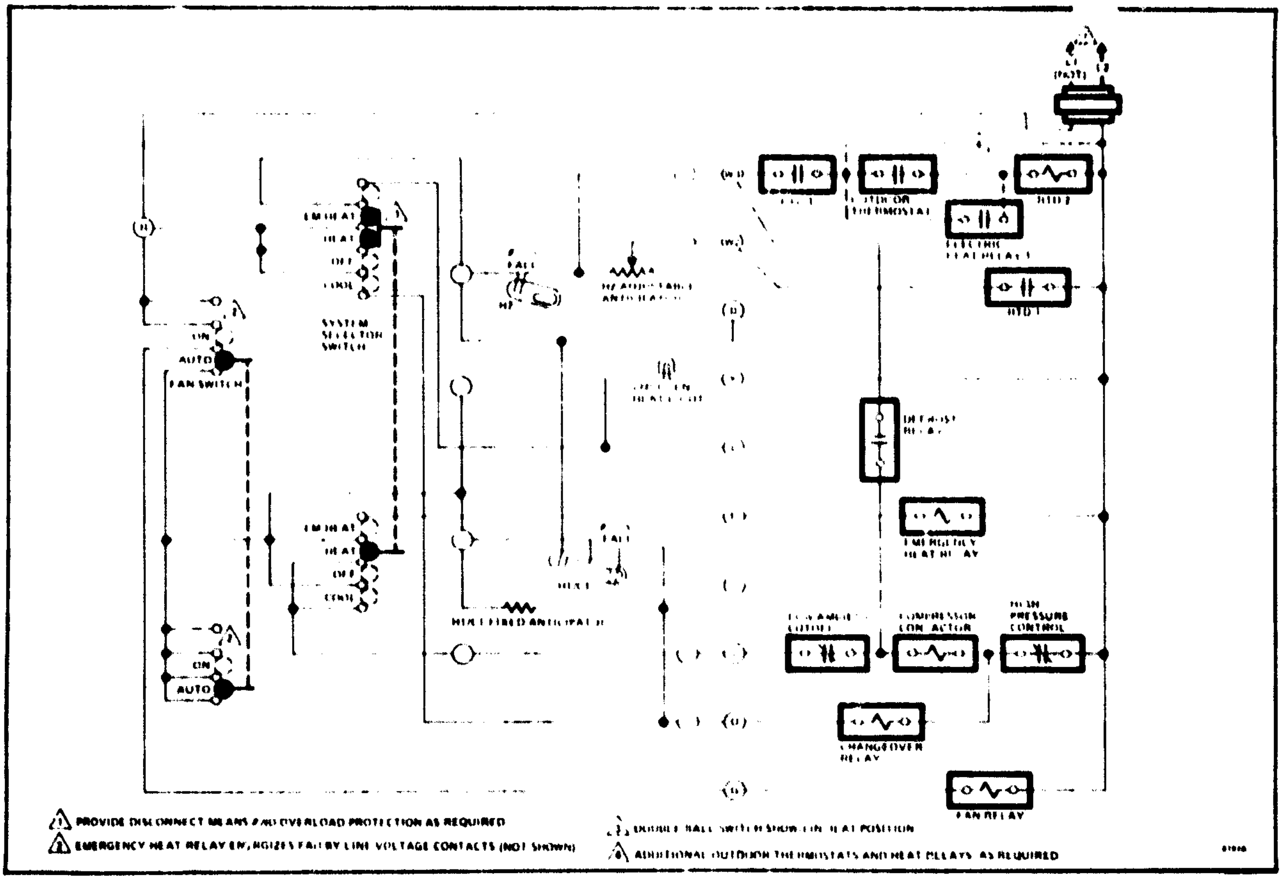


FIG. 50—INTERNAL SCHEMATIC AND TYPICAL HOOKUP OF Q672L/T872R IN HEAT PUMP APPLICATION. THERMOSTAT PROVIDES 2-STAGE HEATING AND 1-STAGE COOLING; MANUAL CHANGEOVER OPERATES ON COOLING. FAST CYCLING STAGE 2 HEAT HAS ISOLATED CIRCUIT AND SEPARATE TRANSFORMER. EMERGENCY HEAT RELAY AND LIGHT ARE ENERGIZED IN EM.HT. SWITCH POSITION. SUBBASE PROVIDES EM.HT.-HEAT-OFF-COOL SYSTEM AND AUTO-ON FAN SWITCHING.

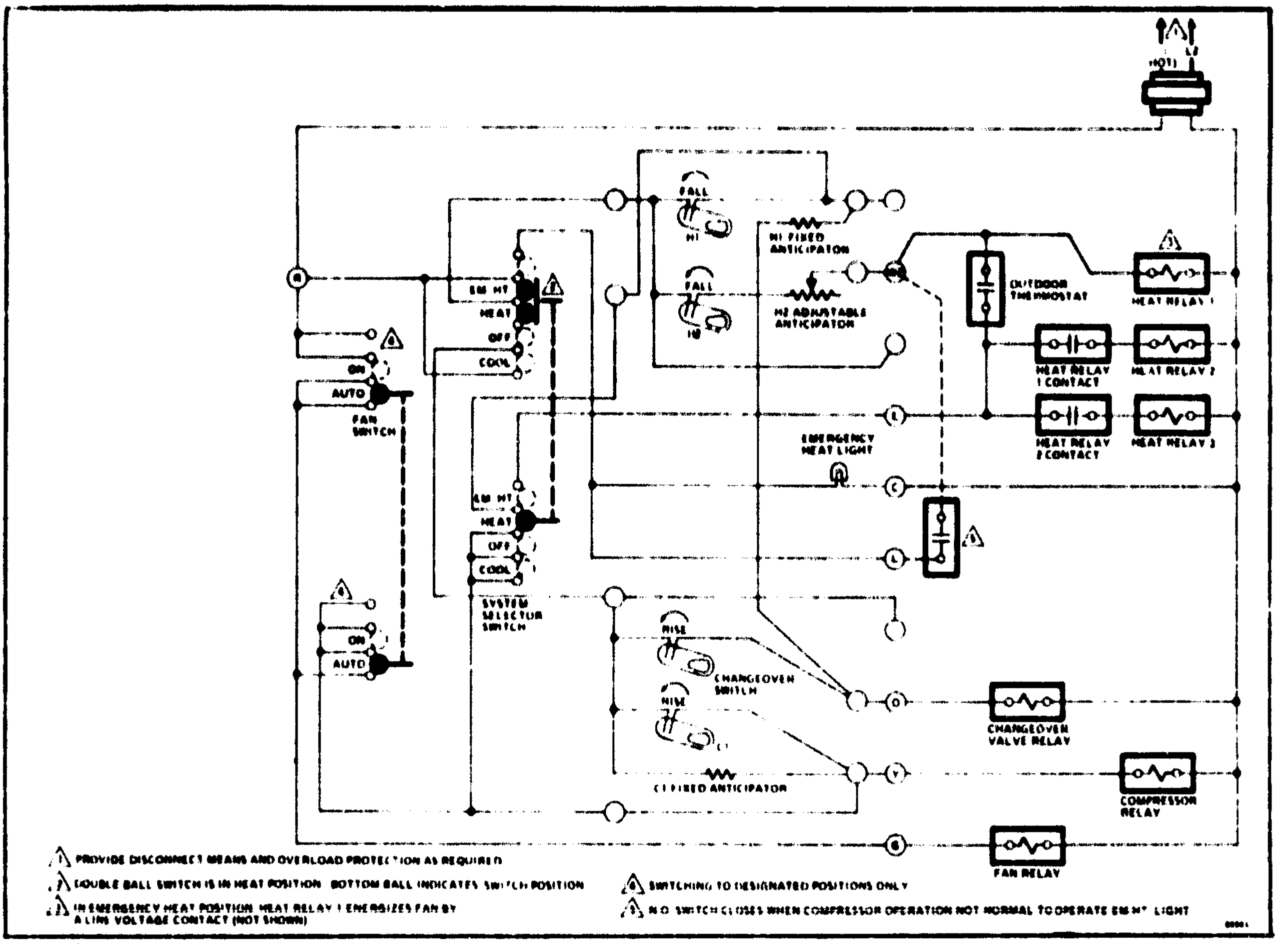


FIG. 51—INTERNAL SCHEMATIC AND TYPICAL HOOKUP OF Q672L/T872G IN HEAT PUMP APPLICATION. THERMOSTAT PROVIDES 2-STAGE HEATING AND 1-STAGE COOLING; MANUAL CHANGEOVER OPERATES ON COOLING. SUBBASE PROVIDES EM.HT.-HEAT-OFF-COOL SYSTEM AND AUTO-ON FAN SWITCHING.

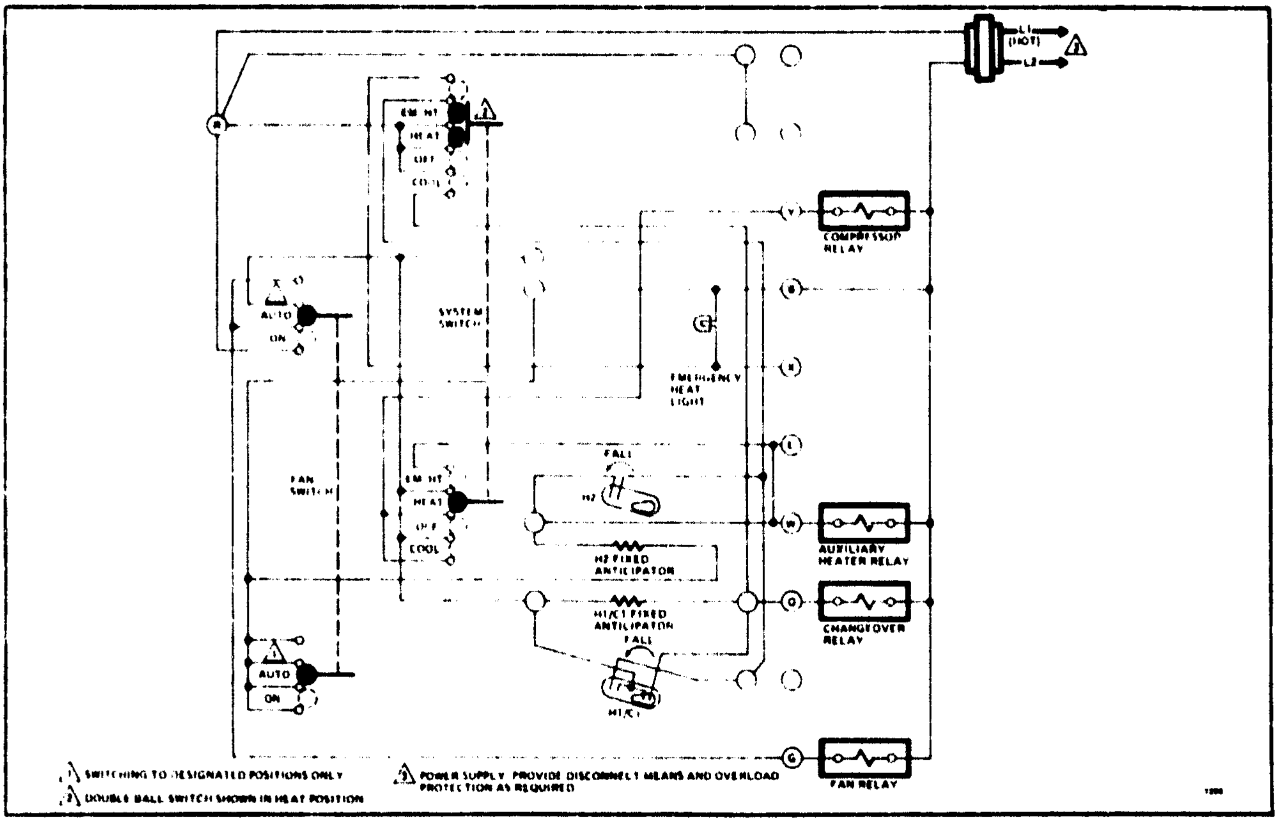


FIG. 52—INTERNAL SCHEMATIC AND TYPICAL HOOKUP OF Q672L/T872R IN HEAT PUMP APPLICATION. THERMOSTAT PROVIDES 2-STAGE HEATING AND 1-STAGE COOLING; MANUAL CHANGEOVER OPERATES ON COOLING. SUBBASE PROVIDES EM.HT.-HEAT-OFF-COOL SYSTEM AND AUTO-ON FAN SWITCHING.

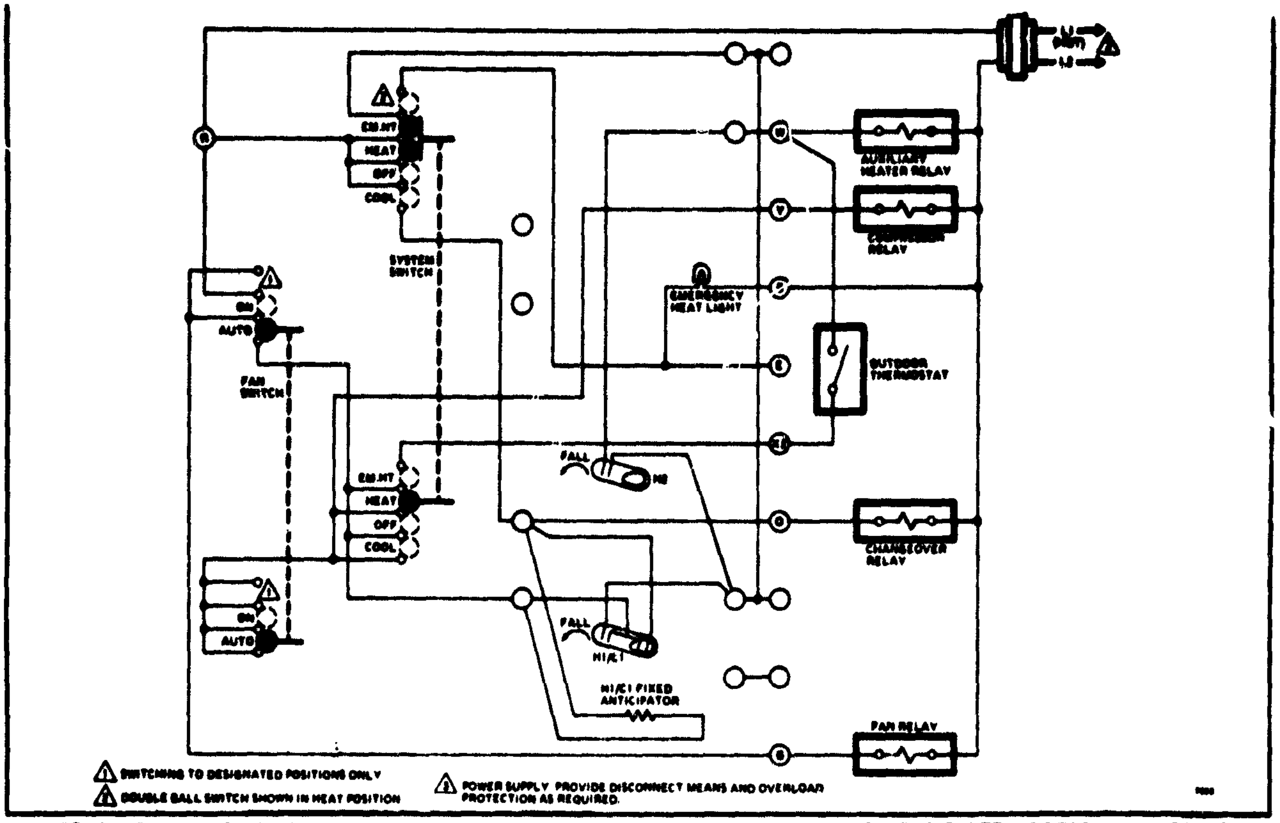


FIG. 53—INTERNAL SCHEMATIC AND TYPICAL HOOKUP OF Q672L/T872R IN HEAT PUMP APPLICATION. THERMOSTAT PROVIDES 2-STAGE HEATING AND 1-STAGE COOLING; MANUAL CHANGEOVER OPERATES ON COOLING. SUBBASE PROVIDES EM. HT.-HEAT-OFF-COOL SYSTEM AND AUTO-ON FAN SWITCHING.

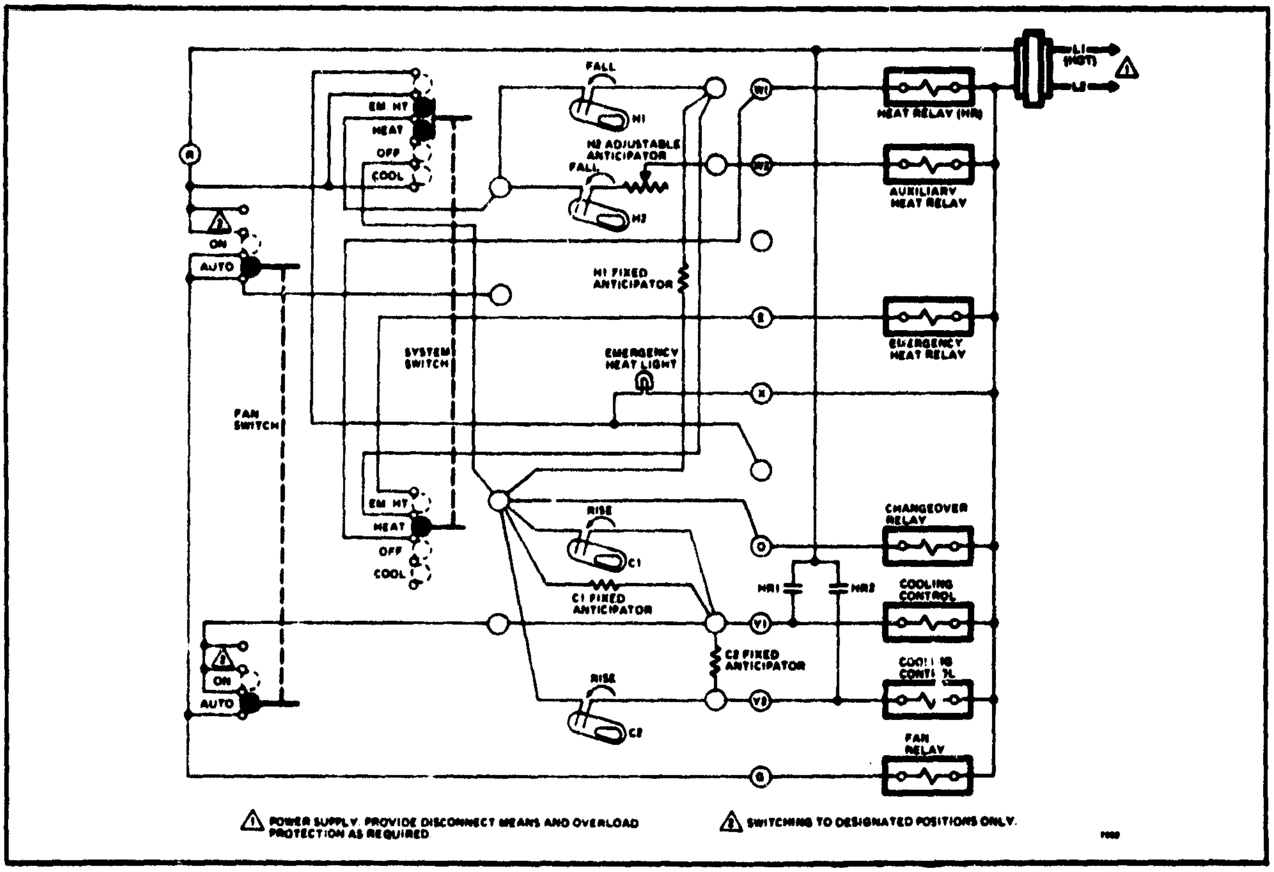


FIG. 54—INTERNAL SCHEMATIC AND TYPICAL HOOKUP OF Q672L/T872G IN HEAT PUMP APPLICATION. THERMOSTAT PROVIDES 2-STAGE HEATING AND 2-STAGE COOLING. SUBBASE PROVIDES EM. HT.-HEAT-OFF-COOL SYSTEM AND AUTO-ON FAN SWITCHING.

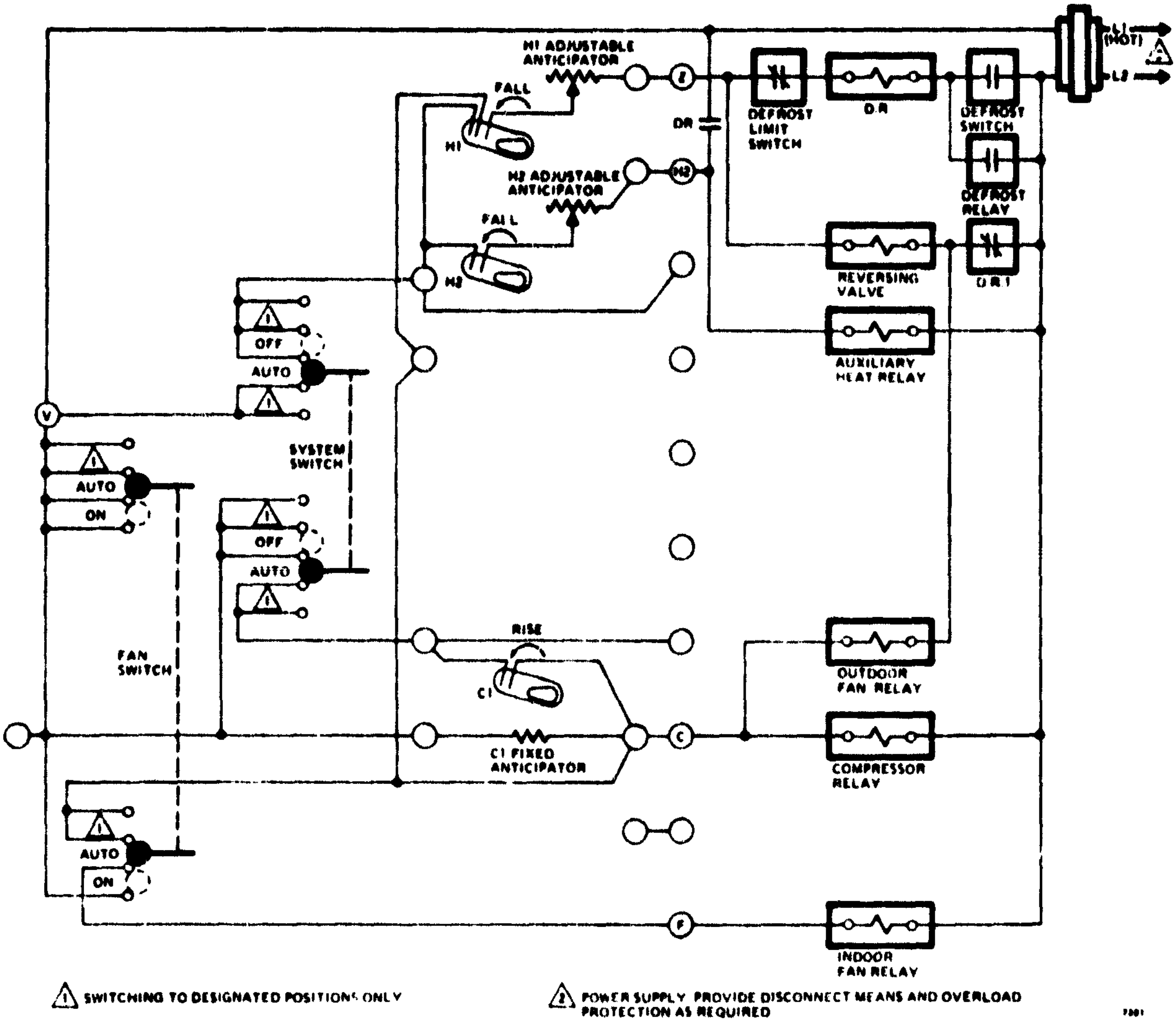


FIG. 55—INTERNAL SCHEMATIC AND TYPICAL HOOKUP OF Q672C/T872S IN HEAT PUMP APPLICATION. THERMOSTAT PROVIDES 2-STAGE HEATING AND 1-STAGE COOLING; CHANGEOVER VALVE OPERATES WITH HEATING. SUBBASE PROVIDES OFF-AUTO SYSTEM AND AUTO-ON FAN SWITCHING.

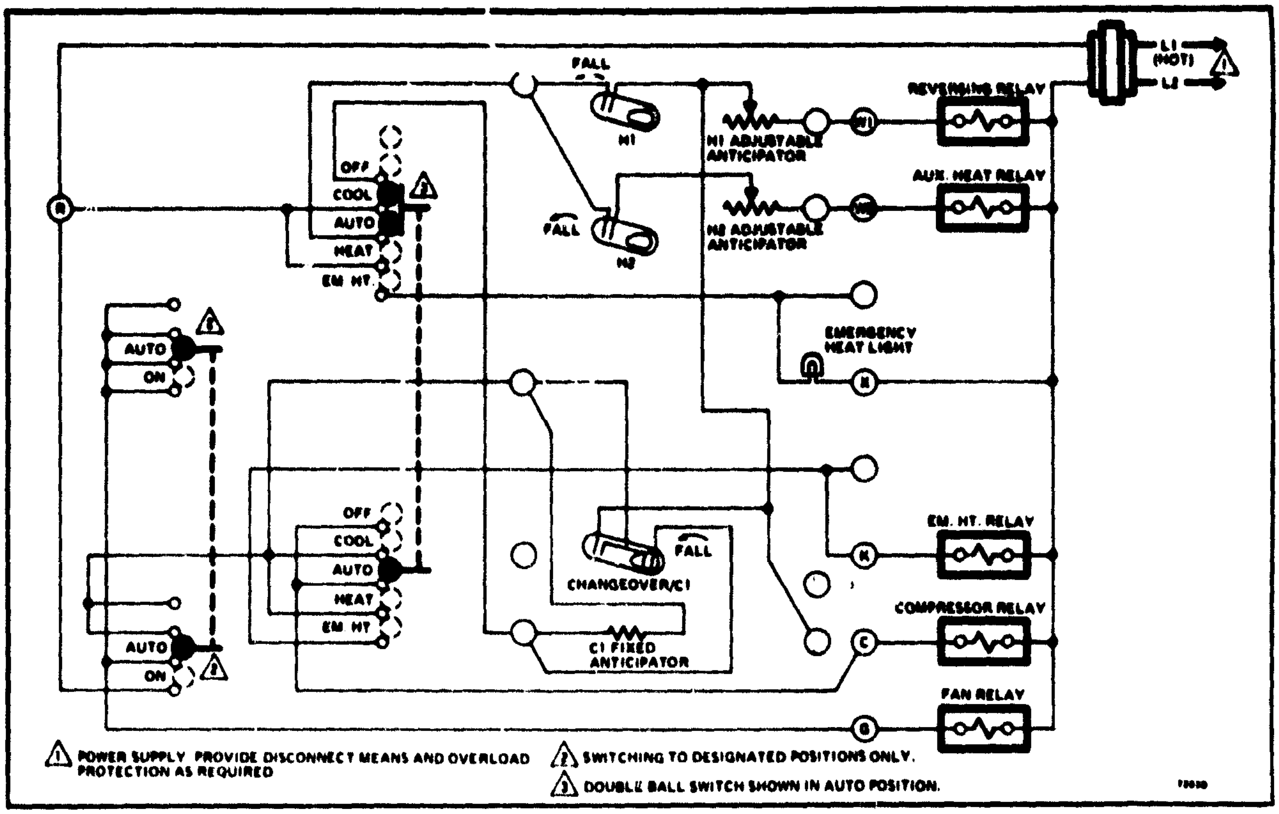


FIG. 56—INTERNAL SCHEMATIC AND TYPICAL HOOKUP OF Q672F/T872N IN HEAT PUMP APPLICATION. THERMOSTAT PROVIDES 2-STAGE HEATING AND 1-STAGE COOLING; CHANGEOVER VALVE OPERATES WITH HEATING. SUBBASE PROVIDES OFF-COOL-AUTO-HEAT-EM.HT. SYSTEM AND AUTO-ON FAN SWITCHING.

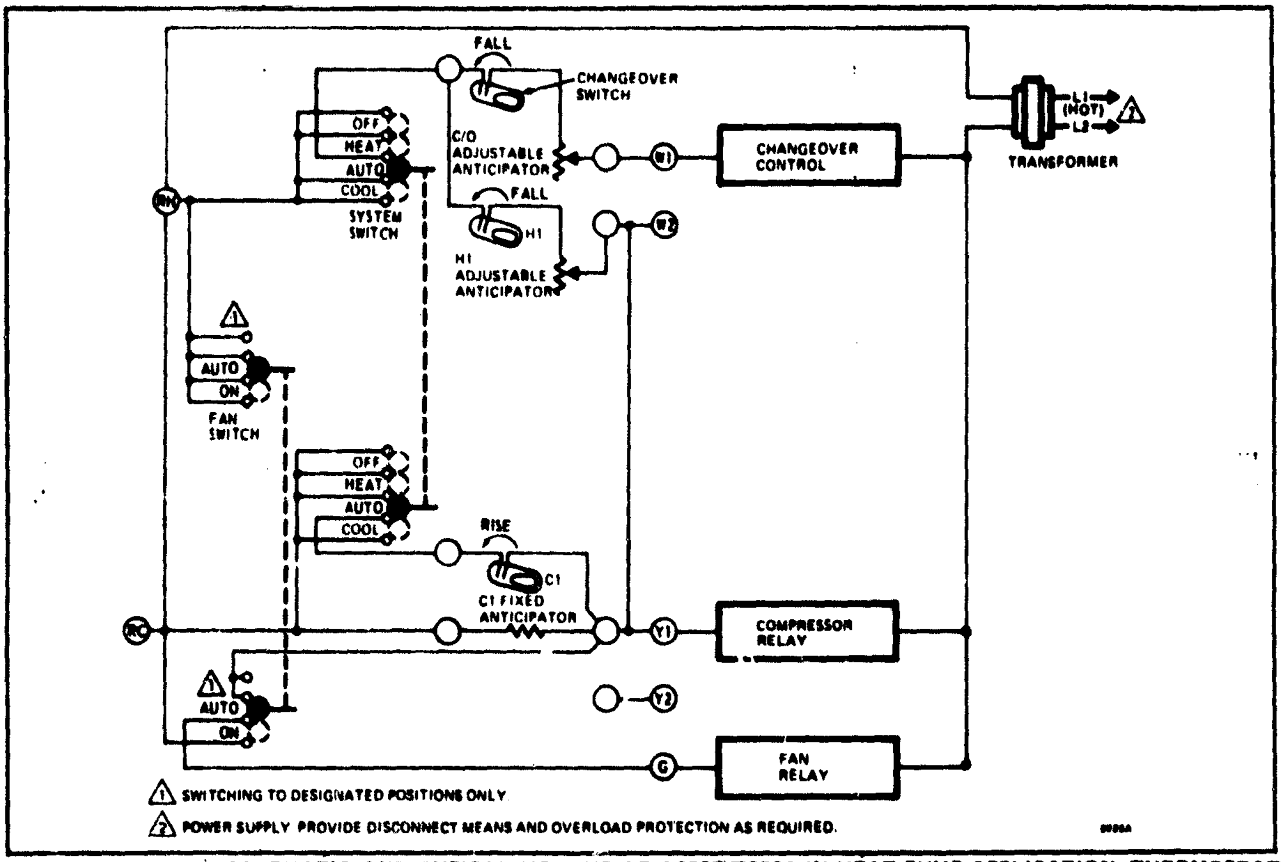


FIG. 57—INTERNAL SCHEMATIC AND TYPICAL HOOKUP OF Q672E/T872C IN HEAT PUMP APPLICATION. THERMOSTAT PROVIDES 1-STAGE HEATING AND 1-STAGE COOLING; CHANGEOVER VALVE OPERATES WITH HEATING. SUBBASE PROVIDES OFF-HEAT-AUTO-COOL SYSTEM AND AUTO-ON FAN SWITCHING.

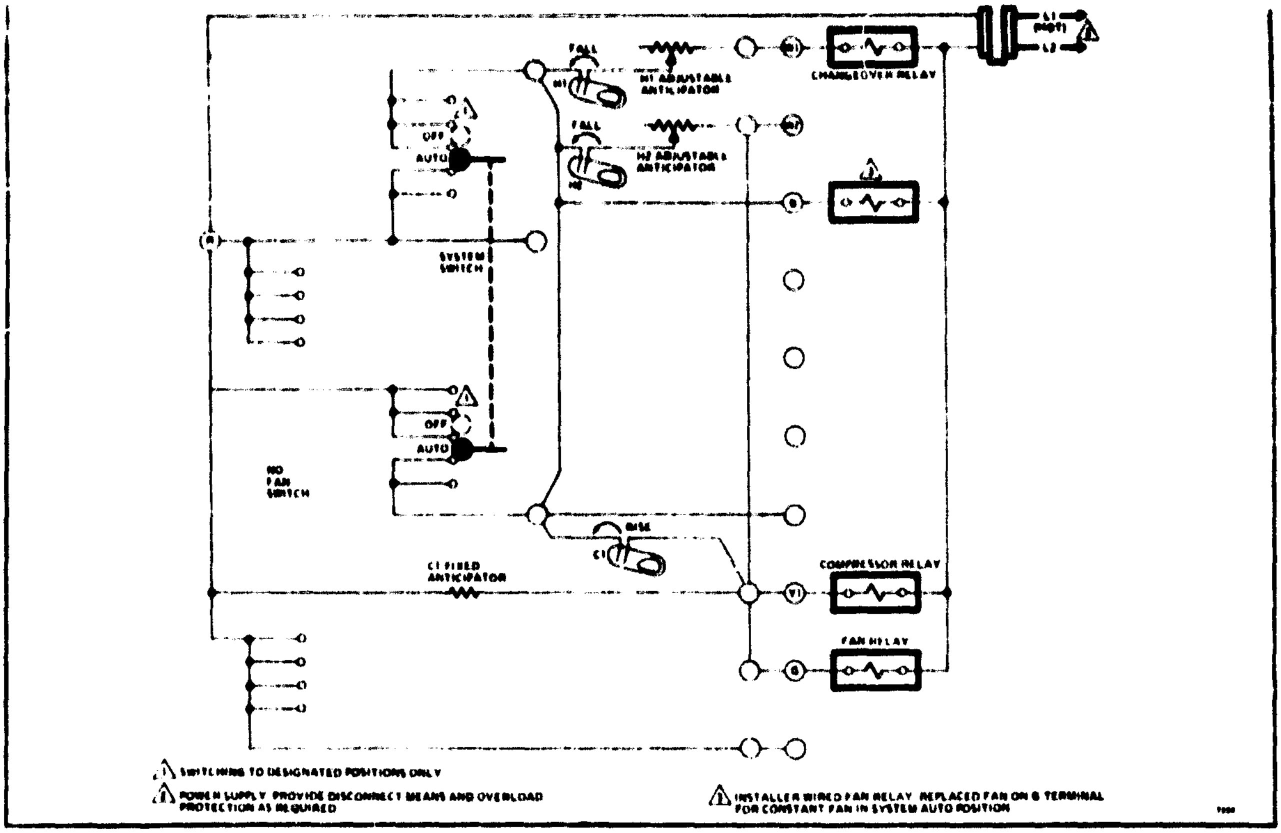


FIG. 58—INTERNAL SCHEMATIC AND TYPICAL HOOKUP OF Q672G/T872C IN HEAT PUMP APPLICATION. THERMOSTAT PROVIDES 1-STAGE HEATING AND 1-STAGE COOLING; CHANGEOVER VALVE OPERATES WITH HEATING. SUBBASE PROVIDES OFF-AUTO SYSTEM SWITCHING AND NO FAN SWITCHING FOR FAN CIRCUIT.

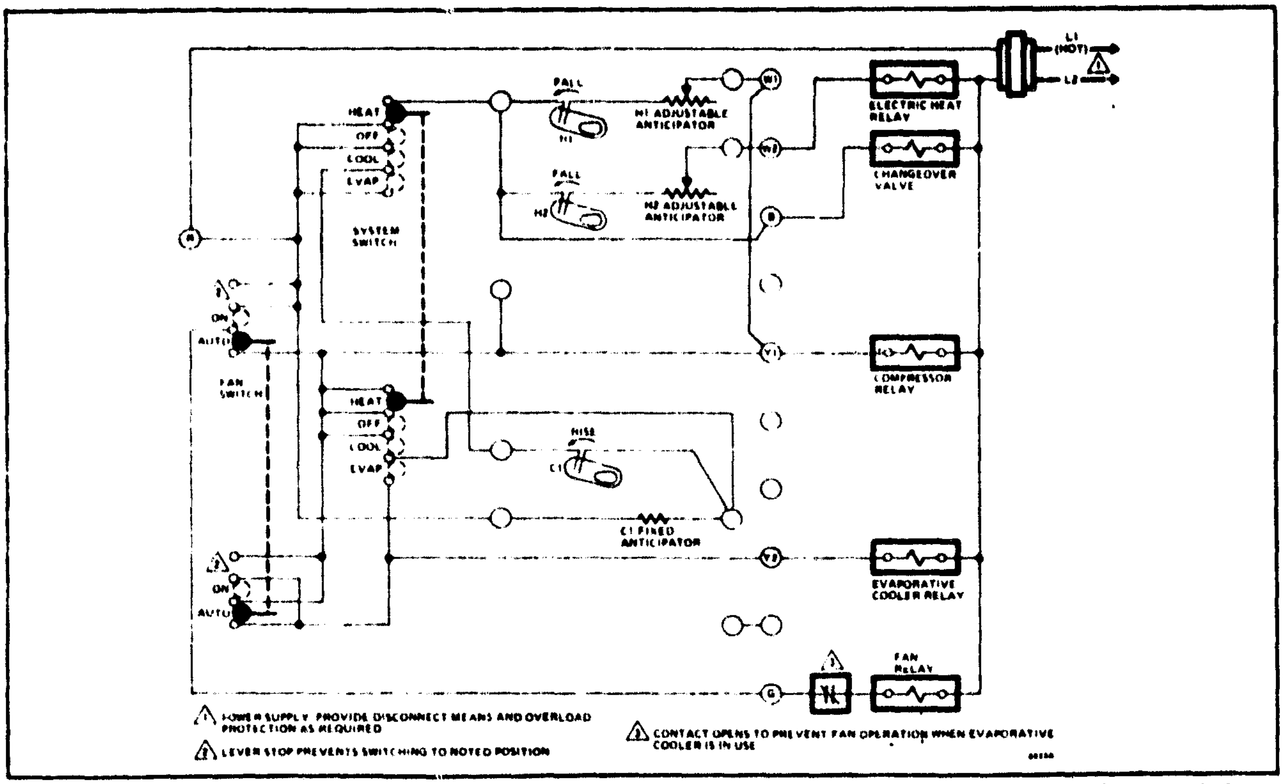


FIG. 59—INTERNAL SCHEMATIC AND TYPICAL HOOKUP OF Q672N/T872C IN HEAT PUMP APPLICATION. THERMOSTAT PROVIDES 2-STAGE HEATING AND 1-STAGE COOLING; CHANGEOVER VALVE OPERATES WITH HEATING. SUBBASE PROVIDES HEAT-OFF-COOL-EVAP. SYSTEM AND ON-AUTO FAN SWITCHING.

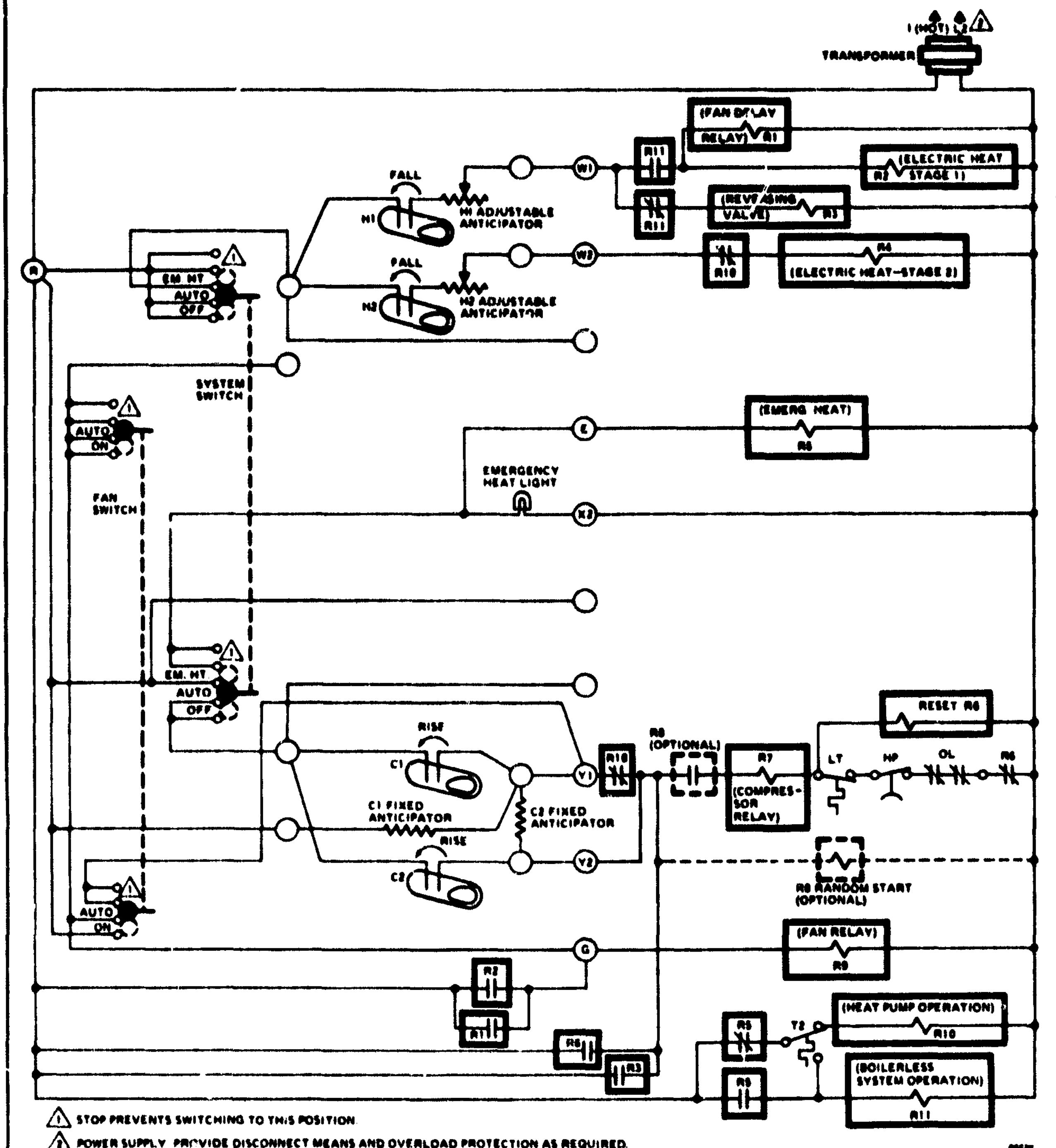


FIG. 60—INTERNAL SCHEMATIC AND TYPICAL HOOKUP OF Q672J/T872A OR D IN HEAT PUMP APPLICATION. THERMOSTAT PROVIDES 2-STAGE HEATING AND 2-STAGE COOLING; CHANGEOVER VALVE OPERATES WITH HEATING. SUBBASE PROVIDES EM.HT-AUTO-OFF SYSTEM AND AUTO-ON FAN SWITCHING.

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PRINTED IN U.S.A.

PRODUCT INFORMATION

MODEL NO. H-1503-A

FIXFLO CONTROL

The Fixflo differential thermostat gives positive on / off control for a wide range of applications. Sensing collector and storage temperatures, the Fixflo applies line voltage to the circulator pump or blower when energy is to be gained from the solar collector panel. Power is removed when no more energy is to be gained.

In domestic hot water, commercial hot water, space heating, and swimming pool applications, the Fixflo has proved itself to be of high quality and reliability. The versatility of this control has been demonstrated by it's use in heat recovery systems and as a precision thermostat. Available features such as recirculating frost protection and upper temperature limit are incorporated into the circuitry of every control and require only the addition of the appropriate optional sensors. Any number of sensors may be wired in parallel (frost) or in series (upper limit) for simultaneous monitoring of multiple points. Hysteresis is also incorporated into the circuitry for stability of operation and minimization of system cycling.

Also available with dual parallel outlets (model H-1505-A).

SPECIFICATIONS:

- Power requirement: 4 watts.
- Power supply regulation for stable operation on line voltages from 105-130V AC, 60 Hz.
- Transformer isolation from power line, 1600V.
- Thermistor sensor voltage: 8.3V DC. Maximum short-circuit current: 4.15 ma.
- All sensor terminals are short-circuit overload protected.
- Controlled AC output: 6 amps (720 watts) at 120V AC. Overload protected with 6A 3AG fuse.
- Varistor line spike and lightning protection.
- Zener diode static charge bleed-off protection at sensor terminals.
- Turn-on differential: 16° F. Turn-off Differential: 3°F.
  - "Power On" light emitting diode indicator.
- Neon indicator lamp shows power applied to output.
- Controller case durable phenolic thermoplastic with black anodized aluminum faceplate and white epoxy silkscreen lettering.
- Case dimensions 6" x 3¼" x 2¼".
- Modular construction for ease of installation and servicing.
- Shipping weight — 2 lbs.
- Applied Research Laboratories approved, Test #21588.

INSTALLATION:

Pressure-sensitive foam tape mounting. Plug-in line voltage connections. Terminal screw low-voltage (sensor) connections.

ORIGINAL PAGE IS OF POOR QUALITY

Hawthorne INDUSTRIES, Inc. Est 1928

SOLAR ENERGY DIVISION

CONTROL SYSTEMS • RESEARCH & DEVELOPMENT

1501 South Dixie • West Palm Beach, Florida 33401 • Phone 305 / 659-5400

ASSEMBLY

Architect: Intergroup Architects

Space Heating / Domestic Water Heating
Make-Up Air Heating / Process Water Heating

Architect: Ames and Thorpe

Space Heating / Domestic Water Heating
Ventilation Air Heating

Architect: Crowther Solar Group

Forced Air Space Heating / Pool Water Heating
Domestic Water Heating

SOLARON CORPORATION

Energy Systems

Solar AIR heating systems produce more usable energy than liquid solar systems. An independent test of side by side air and liquid solar systems at Colorado State University states: ". . . the air system operated 46 percent longer during the day than the liquid system and collected 38 percent more heat." "This is a consequence of stratified heat storage in the pebble bed for the air system and nearly uniform temperature in the water storage tank of the liquid system." This is described in terms of the solar system performance equation on page four of this brochure.

The SOLARON AIR COLLECTOR offers the following advantages:

- 10 Year performance warranty.
- Safe, reliable and virtually maintenance-free operation.
- Freedom from damage by freezing or boiling.
- Absence of pipes which can corrode and leak.
- Requires no antifreeze or stagnation protection controls.
- Approved by HUD and ERDA for Federally funded projects.

MR—MANUFACTURER

Solaron's business is the practical application of solar energy. We design, manufacture and market solar heating systems for industrial, commercial, agricultural products drying and residential buildings. The heart of our system is the air-type solar collector, a design based on over 30 years research and development by Dr. George Löf. To contact the nearest Solaron dealer, call the SWEETS BUYLINE.

Design Assistance: Solaron has a complete design manual covering all aspects of solar system engineering, architectural requirements and economics. Contact Solaron for a copy of the design manual. Experienced and technical personnel are available to assist on any special applications.

The Solar Air Heating Sys

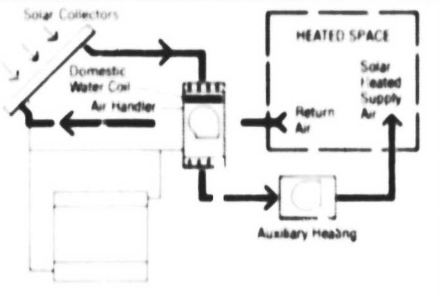
SOLARON CORPORATION T.M.

The Solaron solar heating system is marketed throughout the U.S. by local distributors and dealers who are well established in the HVAC industry. The Solaron distributors maintain a complete stock of Solaron equipment. The distributors, who also handle major brands of heating and air conditioning equipment, work with dealers who are HVAC installing contractors. The Solaron dealers are established and reliable contractors who are familiar with installing heating equipment and associated ductwork. Both the distributors and dealers are thoroughly trained by Solaron in all aspects of solar heating, design, equipment application and installation. Solaron engineers and field servicemen support the distributors and dealers as required, and provide on site assistance.

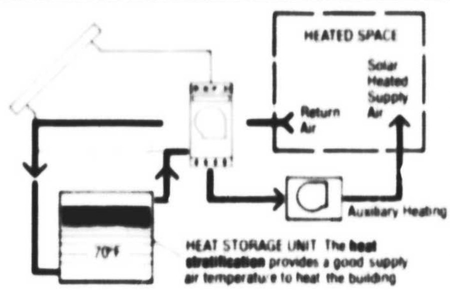
The Solaron collector, air handler and controller and necessary ductwork is installed by the HVAC contractor. The general contractor usually builds the heat storage container. The system is then tested through all of the operating modes and thoroughly checked for proper operation.

OP—OVERALL PRODUCT, IN PLACE

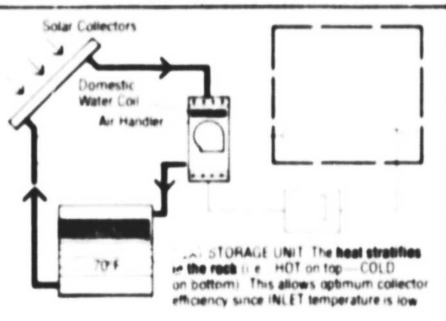
SYSTEM OPERATION



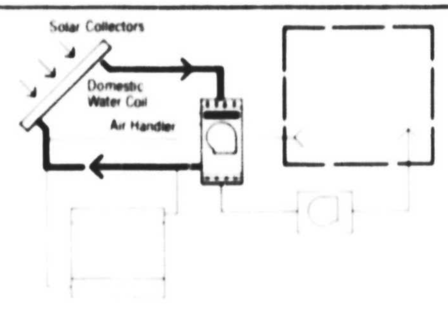
HEATING FROM COLLECTOR Air, the circulating heat transfer medium is drawn through the collector where it is normally heated to about 120-150°F. When the space requires heat, the solar heated air is drawn through the air handling unit in which motorized dampers are automatically opened to direct the hot air to the space. The air then returns to the collector where it is again heated and the cycle repeats itself.



HEATING FROM STORAGE At night or on cloudy days when solar energy is unavailable and when heat is needed in the space, the automatic control system directs the building return air into the bottom of the heat storage unit, up through the pebbles where the air is heated, through the air handling unit and into the space. When the solar heated air does not maintain the space thermostat setting, the automatic control turns on the auxiliary heater to add to the required heat.

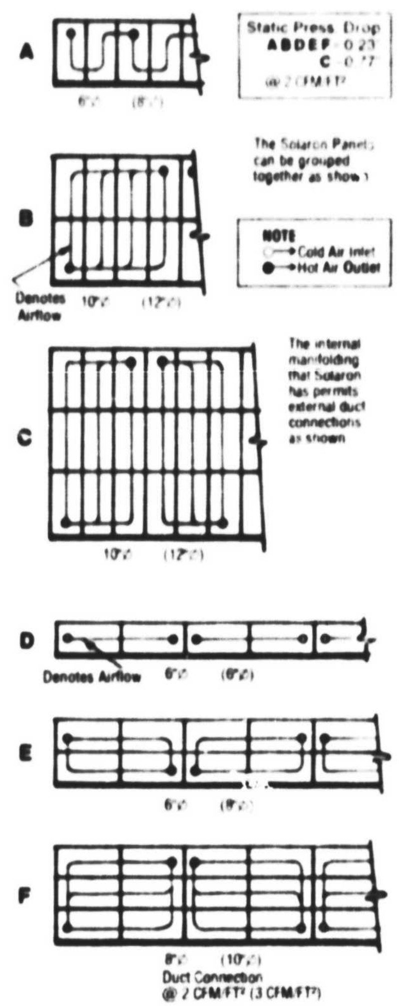


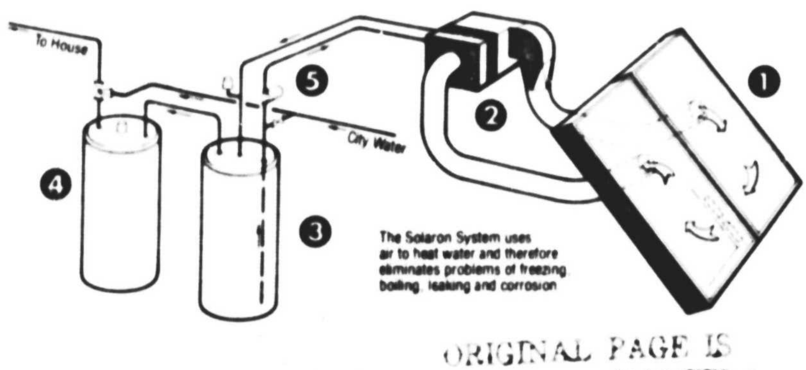
STORING HEAT When the space temperature is satisfied the automatic control system diverts the air into the heat storage unit where the heat is absorbed by the pebble bed. The air returns to the collector where it is heated and this cycle is repeated.



SUMMER WATER HEATING In the summer, when space heating is not required, air is drawn through the collector where it is heated and then through the water heat exchanger coil. The solar heated air transfers its heat to the water which is being circulated through the coil and the air is then returned back to the collector inlet.

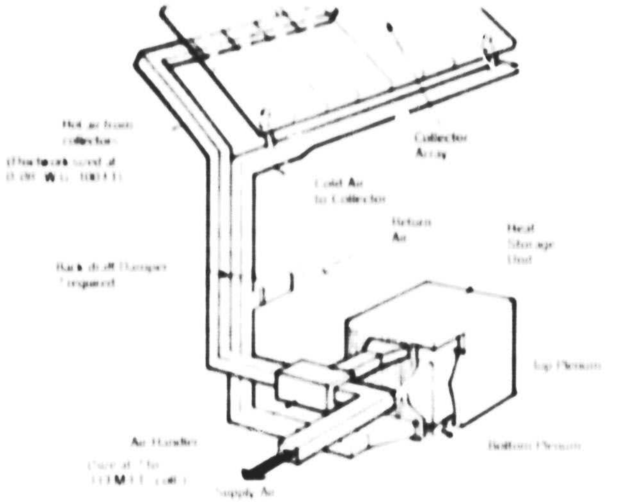
TYPICAL COLLECTOR ARR





SOLARON DOMESTIC WATER HEATING SYS

The Solaron Domestic Water Heater System involves a very simple operating cycle. Solar energy is collected by the south facing collector **1**. Air is circulated by the heat exchange unit **2** where the solar energy is transferred to the water being circulated by the domestic water circulating pump **5**. Solar heated water is continuously circulated into the storage tank **3** as long as the Solaron control unit indicates that solar energy is available at the collectors **1** and until tank temperature in the storage tank **3** reaches 160 degrees F. When hot water is required water is drawn from the conventional domestic hot water heater **4** and preheated water is drawn from the storage tank **3** into the conventional domestic water heater.

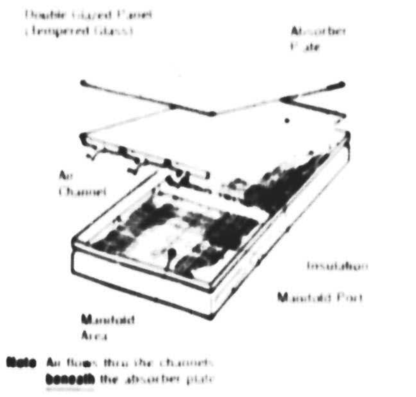


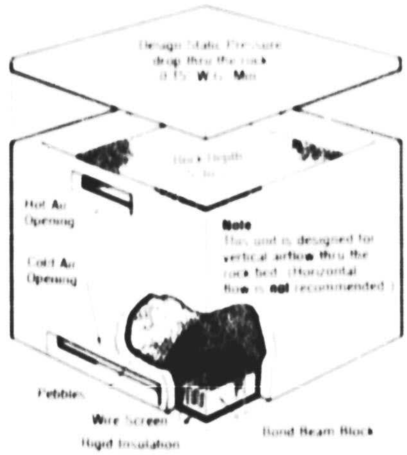
A drawing of a typical installation is shown to the left. The collectors can be grouped as shown or in any of the configurations shown on page 2. Typical Collector Arrays. Due to the Solaron internal manifolding technique (i.e. air flow from one panel to another internally) the external duct connections are minimized as shown above (i.e. one inlet and one outlet for 8 panels, 156 ft²). This technique reduces field labor and leads to an economical installation.

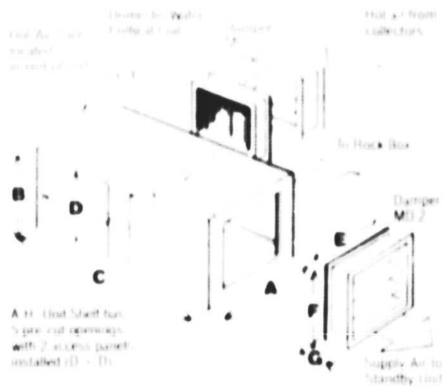
CONTACT SOLARON TO OBTAIN SYSTEM SCHEMATICS SHOWING HOW TO COMBINE SOLAR HEATING WITH:

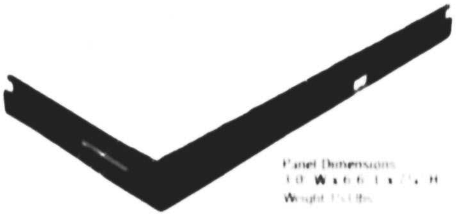
- Heating & air conditioning
- Heat pumps
- V.A.V. systems
- Multiple zones
- Process water heating
- Make up air heating
- Process air htg drying
- Swim pool water htg
- Industrial & agricultural heating

CP — COMPONENTS, PARTS









(patents applied for)

The Solaron solar collector is an advanced type of an air heating, flat plate collector. Our exclusive internal manifolding allows the Solaron collector to be completely modular. Factory preassembled collector panels are plugged into each other with a minimum of installation time. Air inlets and outlets are field cut into each collector array as required. The Solaron solar collector is designed for installation on any structurally sound surface, such as a roof, wall or specially made supports.

The Solaron solar collector has the following general construction characteristics:

Absorber: 28 gauge steel with porcelain enamel coating.

Glazing: Two ⅛" sealed special low iron tempered glass panels with a long life EPDM perimeter gasket. Glass plate can be easily removed for service or replacement.

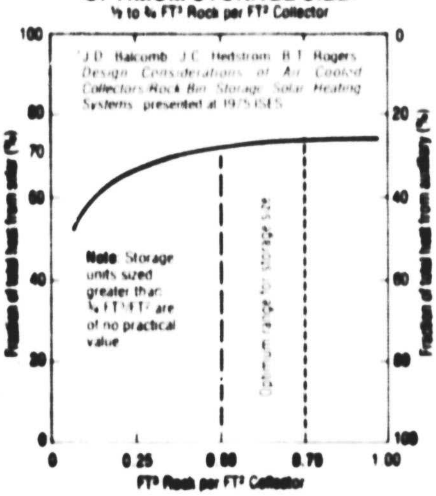
Pan: 20 gauge steel, fully insulated with 3½" fiberglass batt. Painted external surfaces.

Connection Ports: Unique flange configuration permits tight air seal automatically as modules are installed.

Cap Strip: Painted steel designed to provide weather seal between panels.

The use of pebbles in the heat storage unit is particularly effective with an air circulating solar heating system. The pebble bed maintains a steep temperature stratification (i.e. hot on top and cold on the bottom). This allows air to be provided at the highest available temperature to the heated space from the top of the pebble bed. It also allows air to return from the bottom of the bed to the collector at essentially room temperature. This ensures maximum efficiency of solar heat collection and delivery.

OPTIMUM STORAGE SIZE:
½ to ¾ FT³ Rock per FT² Collector



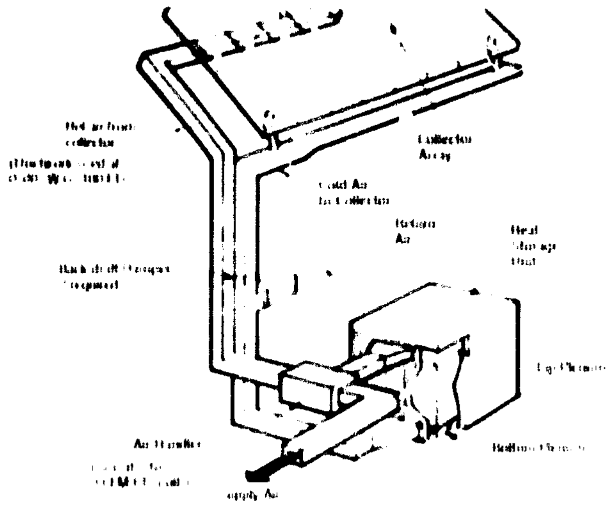
The heat storage unit must be built and installed by the local contractor to Solaron standard drawings and specifications. Contact Solaron for a copy of these specs.

Model No.	Air Handling Unit (in.)				Dampers & Coil			C.F.M. Range at 1.2" S.P.
	A	B	C	D	E	F	G	
AU 0400	20	18	42	14	16	16	8	800 to 1400
AU 0500	24	[illegible]	51	18	20	20	10	1200 to 2400
Larger, custom built air handlers are also available								

Solaron provides a standard factory preassembled air handling unit, including a blower, and motor driven dampers. A separate damper pair is furnished for mounting in the duct system. (i.e. backdraft dampers)

A typical installation for the air handling unit, near the auxiliary heater and heat storage, is shown in the General System Description (upper left). The air handler can be mounted either vertically or horizontally, and with proper orientation and clearance to receive all connecting ducts without interference.

The automatic temperature control unit is included as part of the Solaron system. The controller handles all of the operational modes which are shown in the schematics on page 2. The controller operates the solar side of the system and ties into a 2-stage thermostat to provide solar and/or auxiliary heat to the space as required. The standard controller can be modified (with Solaron hardware) to combine with heat pumps or other types of auxiliary heating systems. Solaron can provide technical assistance to design special controllers for large projects or special applications.



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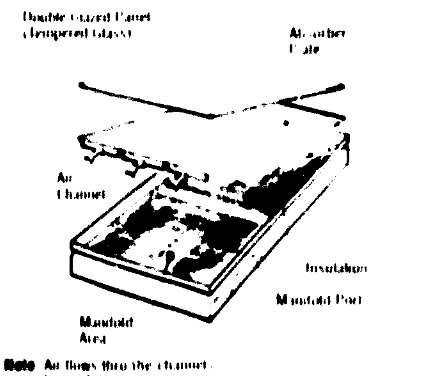
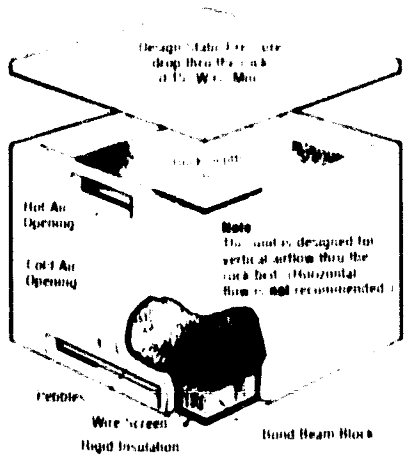
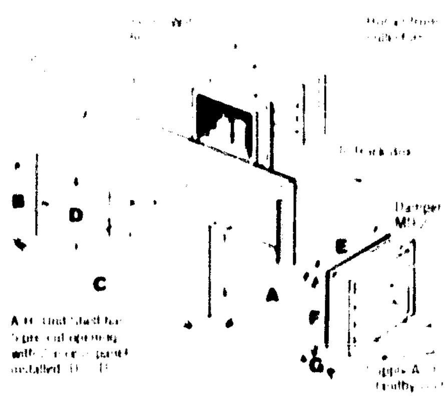
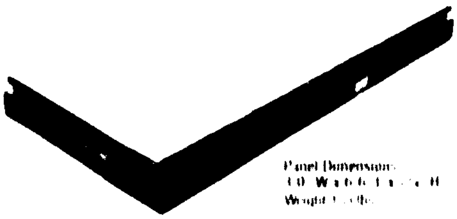


Note Air flows thru the channels **beneath** the absorber plate







Model No.	A	B	C	D	E	F	G	C.F.M. Range
A[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	800 to 1400
A[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1200 to [illegible]

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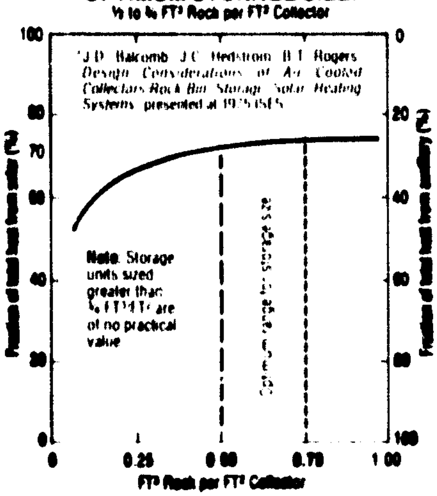

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Comparison of various types of solar heating systems can only be done properly if the entire solar *system* is evaluated over an *entire heating season*. Collector efficiency is an instantaneous point in time measurement and is not a valid parameter to evaluate the solar system performance. The ideal situation fc. a solar system is to keep the fluid inlet temperature to the collector as low as possible and have a high usable temperature for space heating. Therefore, the ideal solar system has heat stratified in the storage unit. An air solar system using rocks as the thermal storage provides this stratification. Therefore, the inlet temperature to an air collector is typically 70°F where the liquid collector inlet temperature is 130°F.

$$\left| \frac{Q}{A} = F_R[H_T \tau\alpha - U_L(T_i - T_a)] = \frac{BTU}{Ft^2\ Day} \right|^{*}$$

[gains] [losses]

Two collectors of similar construction can be compared using the performance equation. When the average collector inlet temperature (T_i) is used, the liquid systems produce almost the same heat output as the air system.

$$\text{AIR}\ \frac{Q}{A} = 0.69[(300)(0.75) - (.58)(70° - 40°)] = 139\ \frac{BTU}{Ft^2\ Day}$$

$$\text{LIQUID}\ \frac{Q}{A} = 0.90[(300)(0.75) - (0.8)(130° - 40°)] = 138\ \frac{BTU}{Ft^2\ Day}$$

However, this is still an instantaneous point in time measurement which doesn't take into account the fact that the air system will typically collect for longer periods of time and therefore deliver more total heat output. When these systems are evaluated over an entire season, the results are as reported by the C.S.U. report #C00-2868-1. Because of the stratification, the temperature of the air returning to the collector from the bottom of storage is always near room temperature. Thus, the air collector can deliver useful heat from early morning to late afternoon; the liquid system starts up later in the morning and shuts off earlier in the afternoon. Therefore, when *system performance* is evaluated over an *entire season* it shows that *AIR solar systems actually produce more usable energy than liquid systems*. The C.S.U. tests report that the air solar system delivered considerably more heat output than the same sized liquid system right next to it.

*Ref: Hottel, H.C. and Woertz, B.B. A.S.M.E. Transactions, 64, 91, 1942, Performance of Flat-Plate Solar Heat Collectors

1. Solar Collector Area: The collector area can be determined by using the Solaron Conversion Factors shown to the right. The design heat loss is divided by the S.C.F. to get ft² of collector. Recommendations: Annual fuel savings for space heating should equal 30% to 70%. Annual fuel savings for applications with a more uniform load throughout the year can be higher than 70%.
2. Air Flow Rate: 2 SCFM to 3 SCFM per ft² of solar collector area. Contact Solaron for special applications such as make up air heating, outside air heating for drying or industrial or agricultural process heating.
3. Heat Storage Size: ½ to ¾ ft³ rock per ft² of solar collector area. Rock size ¾" to 1½" diameter.

Example: Project at 40° N. Latitude, 500 ft² Collector Area

1. If Orientation is 20° to the West: The relative collector area required to provide the same annual fuel savings as a system at due South is approximately 1.04 times the calculated collector area. (1.04) × (500) = 520 ft²
2. The optimum collector tilt would be 45° to 55° (i.e. L + 5 to L + 15). If the collectors were at a tilt of 35° (i.e. L - 5) the relative collector area required would be 1.03 × 500ft² = 515ft². If both conditions exist (i.e. 20° West & 35° tilt) the correction would be (1.04) (1.03) (500) = 535.6 ft²

SELECTION EXAMPLE

Given that: A commercial building with a design heat loss = 136,800 BTU/HR, the location is Denver, Colorado and the desired annual fuel savings is 50%.

1. Collector Area = (Design heat loss) ÷ (S.C.F.) = 136,800 ÷ (171) = 800 ft² collector
2. FLOW Rate = (2 SCFM per ft²) × (Collector Area) = (2) × (800) = 1600 SCFM
3. Heat Storage Unit = (½ ft³ rock per ft²) × (Collector Area) = (½) × (800) = 400 ft³ rock

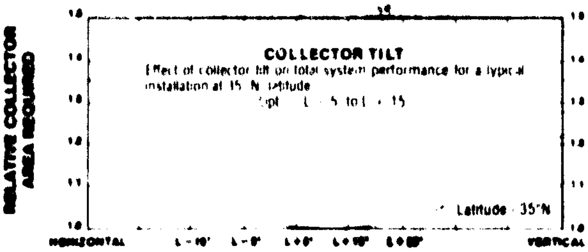
[illegible] CONVERSION FACTORS BY REGION

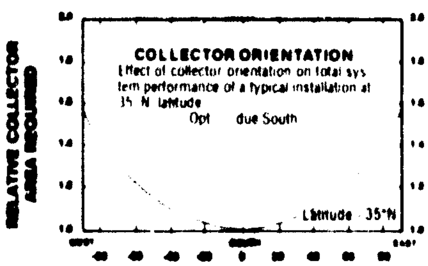
*Solar collector area = (design heat loss $\frac{BTU}{HR}$) ÷ (S.C.F.) ft²

	Location	Design ΔT	Fuel Savings/yr 30%	50%	70%
Az	Phoenix	45	556	293	[illegible]
Ar	Little Rock	55	212	112	68
Ca	Davis	40°	240	113	60
	Los Angeles	30°	421	218	130
	San Francisco	37°	258	127	70
Co	Denver	70°	315	171	104
Fl	Gainesville	38°	458	247	[illegible]
Ga	Atlanta	55°	297	150	86
Id	Boise	60°	205	99	52
Il	Lemont	70°	167	81	47
In	Indianapolis	64	154	[illegible]	40
Ia	Ames	77	195	9	56
Ks	Dodge City	63	304	158	96
Ky	Lexington	60°	222	106	60
La	New Orleans	35	267	139	84
Me	Portland	70°	191	97	55
Md	Silver Hill	55	191	97	55
Ma	Boston	70°	157	80	47
Mi	East Lansing	70°	119	54	29
Mn	St. Cloud	95	187	108	63
Mo	Columbia	70°	230	112	60
Mt	Great Falls	86	265	139	[illegible]
Ne	Lincoln	70°	225	110	[illegible]
Nv	Las Vegas	50°	411	216	[illegible]
N.J.	Seabrook	55	160	74	45
N.M.	Albuquerque	60°	487	309	[illegible]
N.Y.	Albany	70°	160	80	[illegible]
	N.Y.C.	55	138	67	[illegible]
N.C.	Raleigh	55	283	141	87
N.D.	Bismarck	89°	276	111	[illegible]
Oh	Cleveland	63	[illegible]	58	9
	Columbus	63	141	67	[illegible]
Ok	Oklahoma City	60°	319	159	[illegible]
Or	Medford	55	171	80	[illegible]
Pa	State College	64	140	66	[illegible]
R.I.	Newport	59°	169	87	[illegible]
S.C.	Charleston	40°	333	180	[illegible]
S.D.	Rapid City	[illegible]	266	117	[illegible]
Tn	Nashville	60°	218	107	60
Tx	Ft. Worth	50°	350	194	[illegible]
	Midland	55	416	211	[illegible]
Ut	Salt Lake City	[illegible]	213	120	[illegible]
Va	Mt. Weather	60°	177	90	[illegible]
Wa	Seattle	55	168	[illegible]	
	Spokane	70°	170	85	
Washington D.C.		51	149	80	[illegible]
Wi	Madison	80	142	[illegible]	[illegible]
Wy	Lander	87	179	[illegible]	[illegible]
Montreal		80°	119	56	
Toronto		70°	127	59	[illegible]

Note: collector tilt = 54°

*Heating and Air Conditioning Systems Installation Standards for One and Two Family Dwellings and Multifamily Housing Including Solar, The Better Heating & Cooling Bureau, SMACNA, Third Edition, Feb. 1977. Reprinted by permission.





(J.D. Balcomb, J.C. Hedstrom, B.T. Rogers, "Design Considerations of Air Cooled Collector/Rock-Bin Storage Solar Heating Systems," presented at 1975 ISES Los Angeles Meeting, Aug. 1975.)

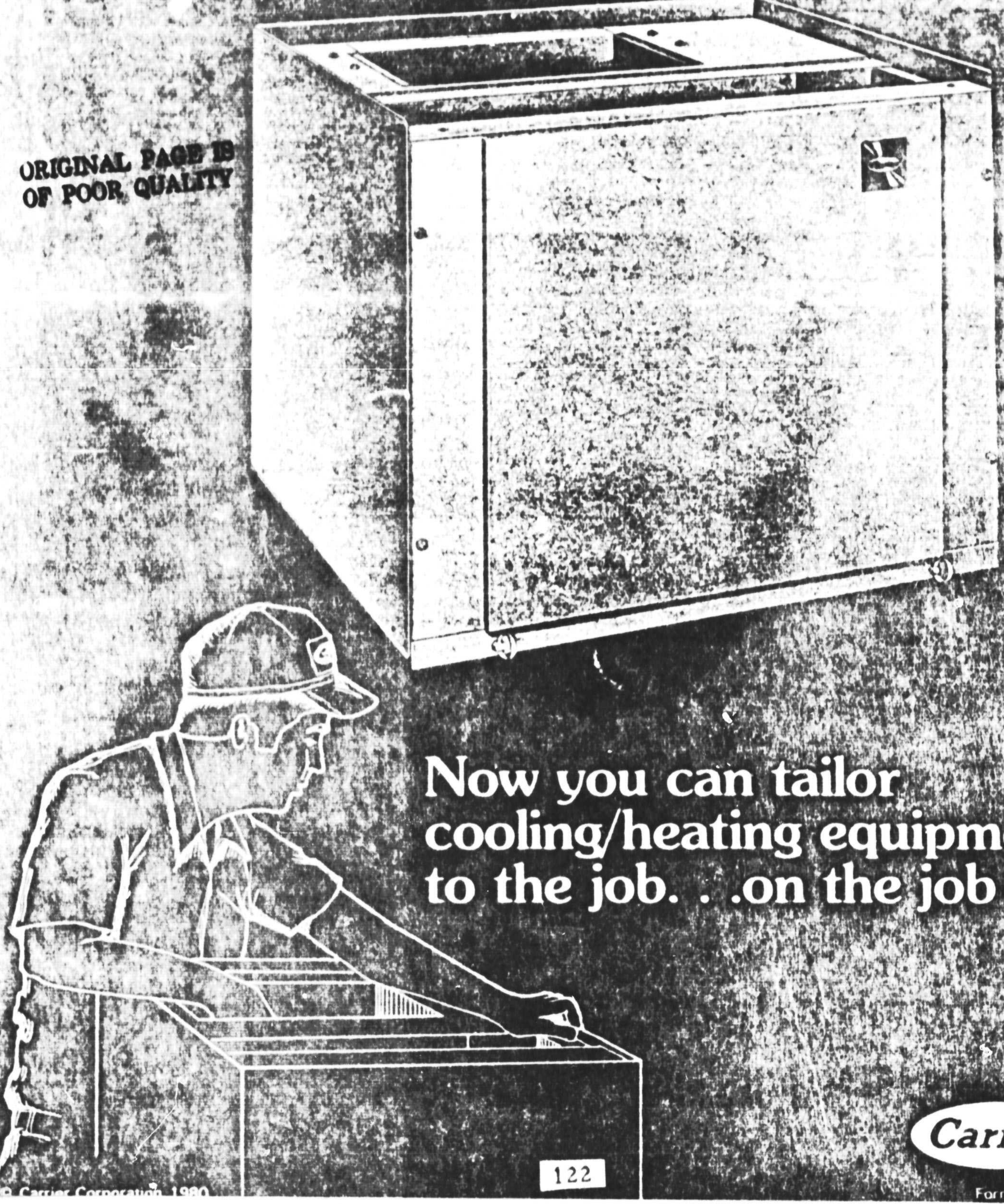
ORIGINAL PAGE IS OF POOR QUALITY

SOLARON CORPORATION™
300 GALLERIA TOWER
720 SOUTH COLORADO BLVD.
DENVER, CO 80222
(303) 759-0101

Carrier Modular Fan Sections

40FS

Nominal air capacities of 1250, 1750 and 2000 cfm



Now you can tailor cooling/heating equipment to the job. . .on the job

Form 40FS-7P

Modules that stack up as the versatile cost savers you've been looking for.

Carrier has brought the modular cooling/heating system concept to residential, apartment, and small commercial installations. Field-assembled units offer some important advantages to builders and developers. New accuracy in equipment selection, more unit flexibility, closer cost control, and greater customer satisfaction once the job is finished.

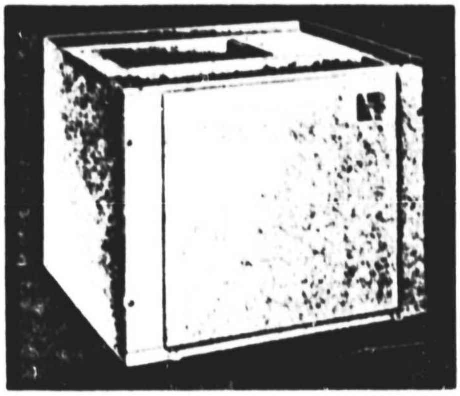
The component that makes it all possible is Carrier's Model 40FS fan module. It's another first for Carrier.

Match the Model 40FS with any of the fully compatible 28 Series slab-type evaporator coils to assemble a fan-coil unit with up to 60,000 Btuh cooling capacity. Most of the coils can be used for cooling only or heat pump duty. Or if you want the most compact electric furnace you ever saw, combine the Model 40FS with a specially designed electric heater, available in sizes to 30 kw. Or stack all 3 together... coil, fan, and heater module... and you have a complete, compact cooling/heating unit. You'll like the custom-built look of the finished unit. And each unit's performance matches its good looks.

Flexibility is a big advantage of these modular units. They can be assembled for upflow, downflow, or horizontal applications...easily and simply. This extra measure of flexibility means greater freedom in system design... greater economy for the builder or developer.

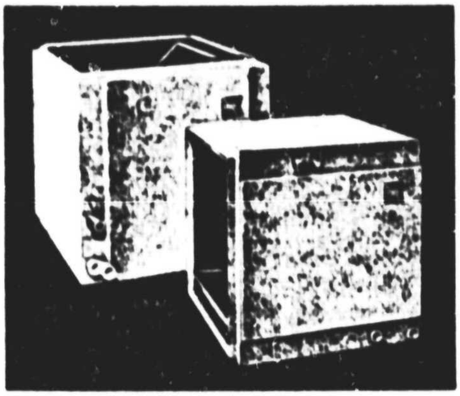
Any of the Model 40FS modular units — fan-coil, electric furnace, or cooling/heating system — can be counted on as space savers. They're designed to be tucked away in a corner, closet, attic, basement, or other convenient spot, and to provide complete service access from the front.

the fan module...



- Three sizes available. Model 40FS160 has a cfm range from 1000 to 1500, 40FS200 from 1500 to 2000 cfm and 40FS220 from 1500 to 2500 cfm.
- Multi-speed, direct drive blower motor with built-in speed selection receptacle for easy, plug-in adjustment of airflow for specific cooling and heating requirements.
- Fully insulated... around the blower and on all 4 sides... keeps operating sound level low as required in today's homes, apartments, and many small commercial establishments such as offices and shops.
- Reversible filter rack with permanent-type filter is standard. On most unit assemblies the filter section can be installed with its duct connection flanges inside or outside unit.
- Accessory cooling control kit installs inside 40FS fan module. Completely assembled and wired cooling controls include a 40-va low-voltage transformer, fan relay, wiring connectors. Kit is required on 230-volt cooling only units.
- Accessory return air plenum for side return air inlet.
- Accessory downflow support angles for Model 40FS916 (universal type) heaters.
- Accessory fan deck package for cooling only applications with universal heaters.

the coils...

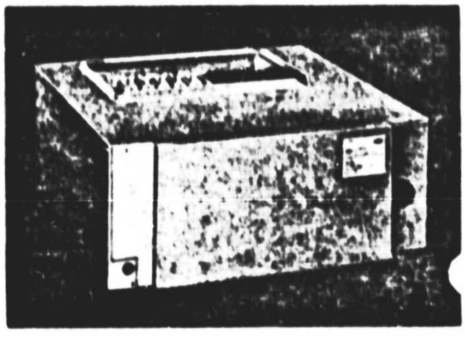


→• Three models... 28VQ,HQ,TQ... nominal capacities 36,000 to 60 000 Btuh. Model 28VQ,HQ for cooling or heat pump system; 28TQ used with 38TQ two-speed heat pump.

- Slab-type, all aluminum coil construction ... insulated casings.
- Compatible Fitting suction and flare liquid line fittings. Externally located for fast installation. It takes only a wrench to connect refrigerant piping.
- AccuRater™ refrigerant flow control adjusts the cooling or heat pump system for optimum cooling heating (in heat pump systems) and dehumidifying.
- Coil fin design and a large, heavy-duty condensate pan(s) slanted to promote fast drainage and eliminate moisture run-off problems.

→• Model 28VQ for upflow or downflow... 28HQ used horizontally only. Model 28TQ is equipped with double drain pans which permit them to be used in upflow, downflow or horizontal applications. (See Application, page 8, for downflow.) Horizontal 28TQ installations require 28TQ accessory condensate collector kit.

the heater module...

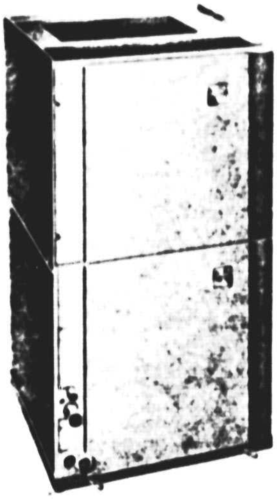


→• 208-240-v, 1- and 3-ph, 60-Hz. Sizes to 30 kw. Use all 40FS heater models in cooling/electric heating systems. The 40FQ heaters are designed especially for heat pump systems. The 38HQ heaters are designed for use with 28HQ dual compressor systems.

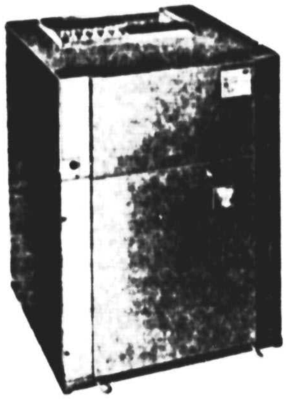
- Module contains controls for cooling and heating including indoor fan relay.
- 24-v transformer (40 va); 60 va on 40FQ and 40FS916320, 330 and 500 models.
- Branch circuit protection as required by National Electrical Code. UL listed.
- Internal fusing standard on units above 10 kw (and on 500 sizes only).
- Sequencing of heater elements in 5-kw increments with time delay between steps.
- Two-stage operation on larger units.
- Overtemperature limit switches with automatic reset. Auxiliary overtemperature fuse links provide back-up protection.
- Heater enclosure is completely insulated.
- Convenient front entry for power and low-voltage wiring.
- Optional circuit breaker heater models.

NOTE: See outdoor condensing unit or heat pump literature for Carrier-approved systems and ARI certified ratings.

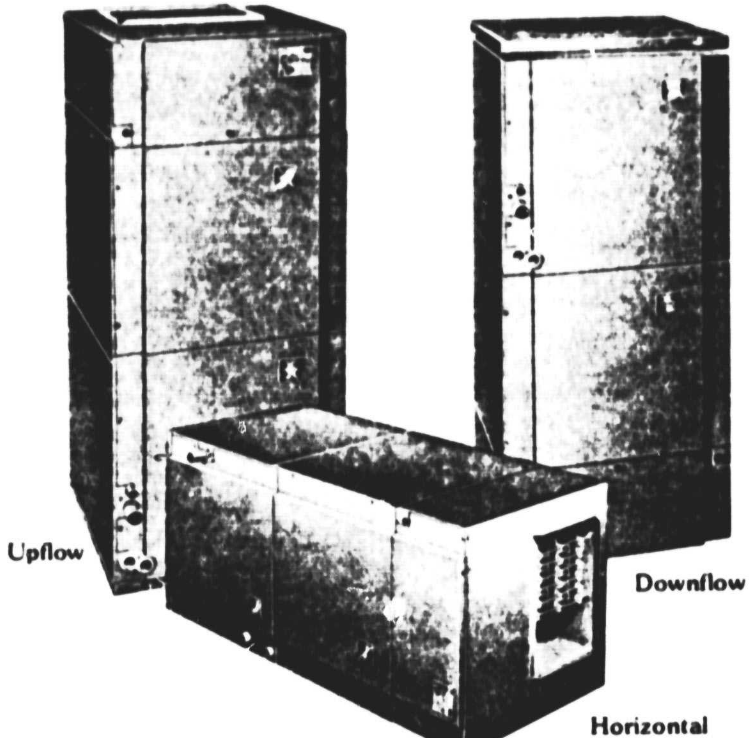
. . .and the arrangement flexibility they provide



FAN-COIL

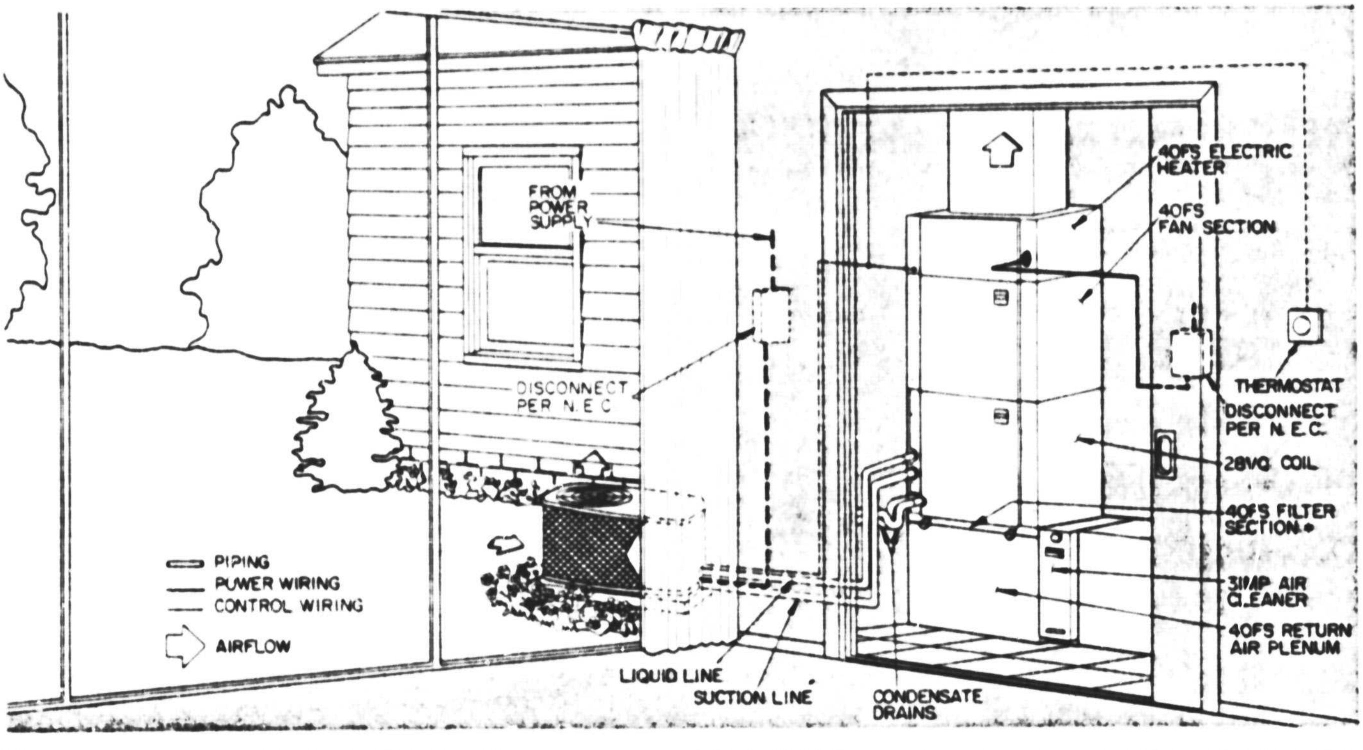


ELECTRIC FURNACE



FAN-COIL — HEATER UNITS

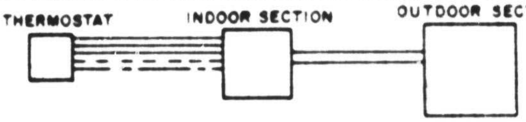
Typical piping and wiring



*Ensure piping does not interfere with filter removal
NOTE: Wiring and piping shown are general guides only. They are not intended for a specific installation.

IMPORTANT: When any fan-coil is installed over a finished ceiling and/or living area, an auxiliary sheet metal condensate pan should be installed under the entire unit.

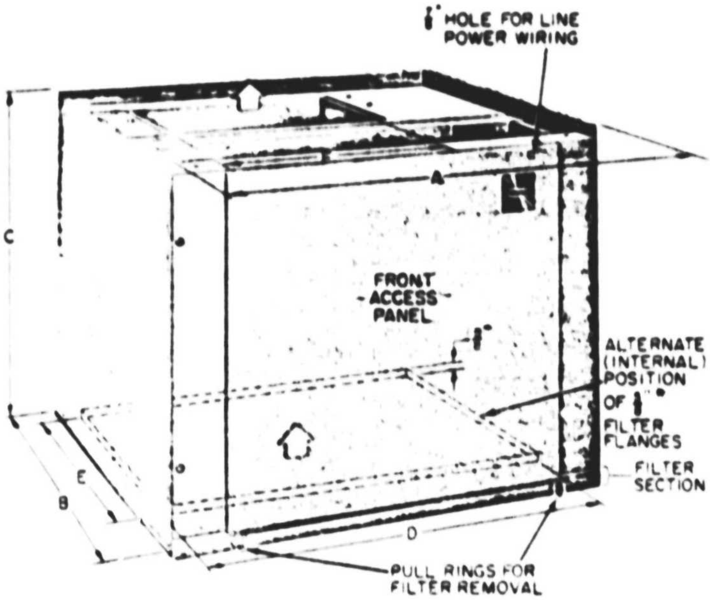
TYPICAL SYSTEM CONTROL WIRING USING INDOOR SECTION CONTROL CIRCUIT (24-V) TRANSFORMER



——— Wiring necessary for cooling without heating.
- - - - - Add to cooling wiring for cooling with one-stage heating.
— — — Add to cooling with one-stage heating wiring for cooling with 2-stage heating.

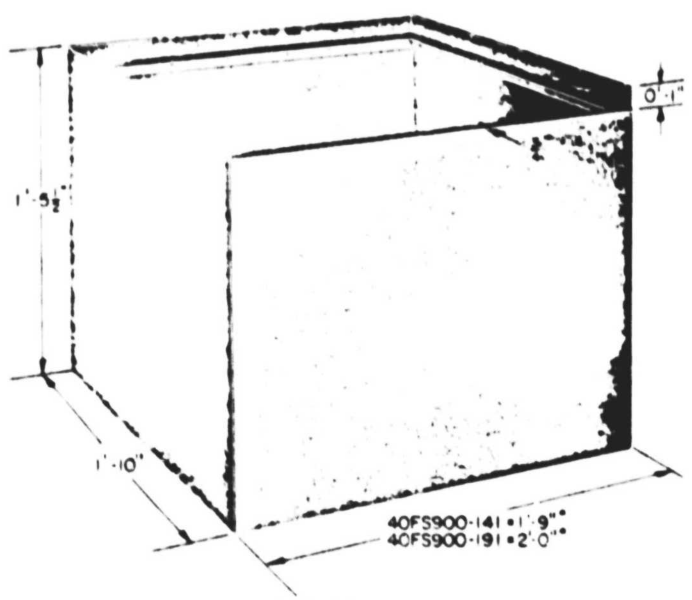
Physical data and dimensions

40FS fan section



*Filter flanges may be reversed to provide external 5/8 in. duct connection flange.

40FS return air plenum
(Solid sides and bottom)



*Use 40FS900141 for 40FS160 assemblies. 40FS900191 for 40FS200 and 40FS220 assemblies.

Airflow

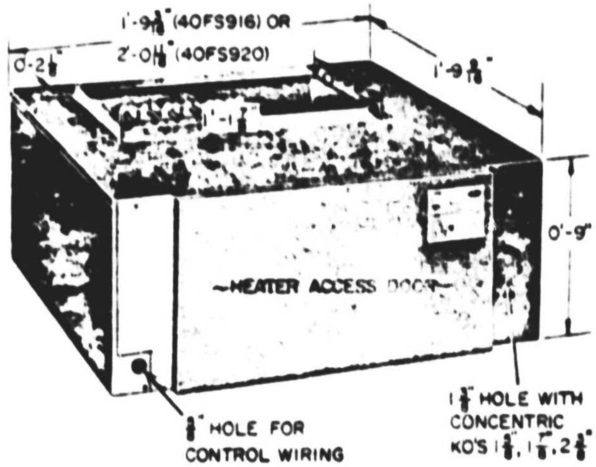
Certified dimension drawings available on request.

FAN SECTION DATA

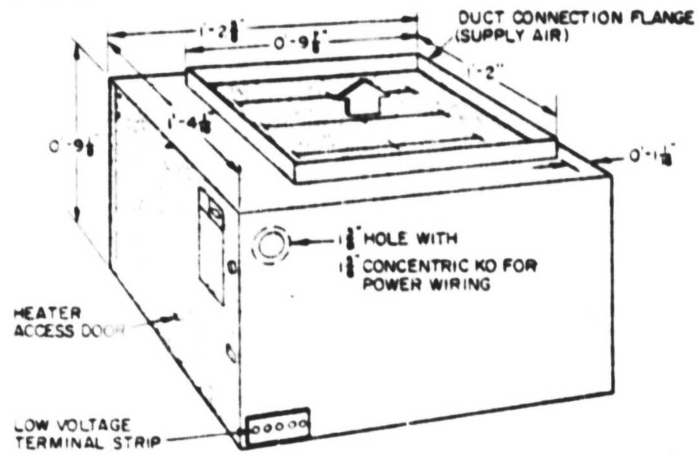
UNIT		40FS160	40FS200	40FS220
OPERATING WT (lb)		60	65	72
FAN				
Rpm, 60-Hz (3-speed)		Centrifugal — Direct Drive 800 to 1100		
Air Discharge		Upflow — Downflow — Horizontal		
Nominal Cfm		1250	1750	2000
PSC Motor — Hp		1/2	3/4	1
DIMENSIONS (ft-in.)				
Length	A	1-9-3/16	2- 0-11/16	
Width	B	1-10-1/16		
Height	C	1- 7-5/16		
DUCT INLET (ft-in.)				
	D	1-7-9/16	1-11-1/16	
	E	1-7		
DUCT OUTLET (ft-in.)				
	F	1- 1-7/8		
	G	0- 9-7/8		
FILTER (1-in. thick)*				
No.		1		
Size (in.)		21x20-3/4	21x24-1/4	

PSC — Permanent Split Capacitor
*40FS units factory equipped with permanent filter and reversible rack with 5/8-in. duct connection flange.

Accessory electric heater
(All 38HQ, 40FS, 40FQ Models except 40FS916320, and 40FS916500 EH, GM and HV Series)



Accessory electric heater
(40FS916320 and 500 EH, GM and HV Universal Series)



Physical data and dimensions (cont)

HEIGHT DIMENSIONS OF ASSEMBLED UNITS

MODULAR UNIT ASSEMBLIES						TOTAL HEIGHT*‡ (ft-in.)	
Cooling and Heating Unit						Airflow	
Cooling Unit					—	Upflow (or Horizontal)†	Downflow
—				Heating Unit			
Coil				Fan Section	Electric Heater		
28HQ036020	28VQ036020	—	—	40FS160	40FS FQ916 38HQ9000**	3 11-13/16	4- 0-7/16
28HQ042030 28HQ048030	28VQ042030 28VQ042030	28TQ042	—	40FS160	40FS FQ916 38HQ9000**	4- 6-7/16	4- 7-1/8
28HQ042020 28HQ048020	28VQ042020 28VQ048020	—	28QX036 28QX042	40FS200	40FS916 920 40FQ920 38HQ9001**	4- 3-5/16 4- 0-3/8††	4- 3-5/16 5- 0-3/8††
28HQ060020	28VQ060020	28TQ060	—	40FS200 220	40FS916 920 40FQ920 38HQ9001**	4- 7-7/16	4- 8-1/16
28HQ036020	28VQ036020	—	—	40FS160	—	3- 3-9/16	3- 4-3/16
28HQ042030 28HQ048030	28VQ042030 28VQ048030	—	—	40FS160	—	3-10-1/4	3-10-7/8
28HQ042020 28HQ048020	28VQ042020 28VQ048020	—	—	40FS200	—	3- 7-1/8	3- 7-3/4
28HQ060020	28VQ060020	—	—	40FS200 220	—	3-11-3/16	3-11-3/16
—	—	—	—	40FS160	40FS FQ916 38HQ9000**	2-4-3/16	
—	—	—	—	40FS200 220	40FS916 920 40FQ920 38HQ9001**		

*Total height may vary slightly depending on electric heater model used
†Length dimension of assemblies in the horizontal position are same as height dimension of units assembled for upflow airflow
‡All height dimensions include 40FS filter section
**For use with 38HQ227 and 234 only
††Total height for 28QX coil with fan section and electric heater
NOTE 020 030 denotes dimensional variation within 28HQ/VQ models. Refer to 28HQ VQ literature for exact dimensions

Performance data

FAN PERFORMANCE

UNIT	CFM	FAN SPEED		
		High	Med	Low
		External Static Pressure (in. wg)*		
40FS160	1000	—	—	82
	1100	—	89	69
	1200	93	79	45
	1300	84	66	—
	1400	75	49	
	1500	64	—	—
40FS200	1500	99	87	59
	1600	92	79	39
	1700	84	69	
	1800	75	58	—
	1900	66	42	—
	2000	56	—	—
40FS220	1500	—	—	1 20
	1600	—	—	1 11
	1700	—	1 39	99
	1800	1 48	1 31	84
	1900	1 44	1 23	—
	2000	1 39	1 14	—
	2100	1 35	1 04	—
	2200	1 30	92	—
	2300	1 24	76	—
	2400	1 18	—	—
	2500	1 11	—	—

*External static pressures shown include a deduction for factory supplied filter (013 in. wg) Subtract loss for cooling coil and/or electric heater to obtain available static pressure for air distribution system at required cfm (Refer to 28VQ HQ TQ Product Literature for coil loss.)

ELECTRIC HEATER STATIC PRESSURE DROP
(Standard Models 38HQ9000, 9001; 40FS916, 920300; 40FQ916, 920; Universal 40FS916500)

CFM	HEATER KW @ 240 V					
	5	10	15	20	25	30
	Pressure Drop (in. wg)					
1000	09	09	10	11	12	12
1100	11	12	13	14	15	16
1200	14	14	16	17	18	19
1300	16	17	19	20	22	23
1400	19	20	22	23	25	27
1500	22	23	25	26	28	31
1600	25	26	28	29	32	34
1700	28	29	31	33	36	39
1800	31	33	35	37	39	43
1900	35	36	39	41	43	47
2000	39	40	43	45	48	52
2100	43	44	47	49	53	57
2200	48	50	52	54	59	63
2300	54	56	59	61	66	71

ELECTRIC HEATER STATIC PRESSURE DROP
(Universal Models* 40FS916320 and 49FS916330)

CFM	HEATER KW @ 240 V			
	5	10	15	20
	Pressure Drop (in. wg)			
1000	13	16	16	17
1100	17	20	20	21
1200	20	23	24	25
1300	23	27	28	30
1400	26	31	32	34
1500	30	36	37	39
1600	33	40	41	44
1700	37	44	46	49
1800	41	49	51	54
1900	45	54	56	59
2000	50	59	32	66
2100	54	65	69	73
2200	60	73	78	85

*Pressure drops shown are for 1-phase universal heaters. For 3-phase universal heaters, use pressure drop listed for standard 40FS/FQ heaters at required Kw and Cfm

Electrical data

HEATER ELECTRICAL DATA AND USAGE

FAN SECTION	Heater Model		Kw 240 V	Kw 208 V	No. Ckts		Heater Amps 240 V	Heater Amps 208 V	Min Wire Size (AWG) 240 V	Min Wire Size (AWG) 208 V	Max Ft Wire 240 V	Max Ft Wire 208 V	Min Gnd Wire Size 240 V	Min Gnd Wire Size 208 V	Fuse/CB Amps 240 V	Fuse/CB Amps 208 V
			ELECTRIC RESISTANCE HEATER (208/240 V)				Branch Circuit									
40FS160	40FS916300 (1-Ph)	DL	8.0	6.0	1	A	33.3	28.9	6	8	60	40	10	10	50**	40**
		DX	9.0	6.8	1	A	37.5	32.5	6	6	55	55	10	10	60**	45**
		EH	10.0	7.5	1	A	41.6	36.1	4	6	80	50	10	10	60**	50**
		ET	11.0	8.3	1	A	45.8	39.7	4	6	75	45	8	10	70	60
		FE	12.0	9.0	1	A	50.0	43.4	4	4	70	65	8	10	70	60
		FQ	13.0	9.8	1	A	54.2	47.0	2	4	100	65	8	8	80	70
		GB	14.0	10.5	1	A	58.3	50.5	2	4	75	60	8	8	80	70
		GM	15.0	11.3	1	A	62.5	54.2	2	2	85	70	8	8	90	80
		JR	20.0	15.0	1	A	83.3	72.2	2†	2	65	65	6	8	110	100
		LW	25.0	18.8	1	A	104.2	90.3	0†	1†	80	65	6	6	150	125
	40FQ916 (1-Ph)	010	8.0	6.0	1	A	33.3	28.9	6†	6†	60	60	10	10	50**	40**
		060*							6†	8†	60	40				
		020	10.0	7.5	1	A	41.6	36.1	4†	6†	80	50	10	10	60**	50**
		070*							6†	6†	50	50				
		030	15.0	11.3	1	A	62.5	54.2	2†	2†	85	70	8	8	90	80
		080*							4†	4†	55	55				
		040	20.0	15.0	1	A	83.3	72.2	1†	2†	85	65	6	8	110	100
		090*							2†	2†	65	65				
		060	25.0	18.8	1	A	104.2	90.3	00†	0†	100	85	6	6	150	125
		100*							0†	1†	80	65				
	38HQ900091 (1-Ph)	61	8.0	6.0	1	A	33.3	28.9	6†	6†	60	60	10	10	50**	40**
									6†	8†	60	40				
		71	10.0	7.5	1	A	41.6	36.1	4†	6†	80	50	10	10	60**	50**
									6†	6†	50	50				
		81	15.0	11.3	1	A	62.5	54.2	2†	2†	85	70	8	8	90	80
									4†	4†	55	55				
		91	20.0	15.0	1	A	83.3	72.2	1†	2†	85	65	6	8	110	100
									2†	2†	65	65				
40FS200 or 40FS220	40FS920300 (1-Ph)	EH	10.0	7.5	1	A	39.6	34.4	4	6	80	50	10	10	60**	60**
		ET	11.0	8.3	1	A	43.6	37.8	4	6	75	45	8	10	70	60
		FE	12.0	9.0	1	A	47.6	39.4	4	4	65	70	8	10	70	70
		FQ	13.0	9.8	1	A	51.6	44.8	2	4	100	60	8	8	80	70
		GB	14.0	10.5	1	A	55.5	48.0	2	4	90	55	8	8	80	70
		GM	15.0	11.3	1	A	59.5	51.6	2	2	85	85	8	8	90	80
		JR	20.0	15.0	1	A	79.3	68.8	1†	2	85	70	6	8	110	100
		LW	25.0	18.8	1	A	99.2	86.0	0†	1†	85	70	6	6	150	125
		PA	30.0	22.5	1	A	119.0	103.2	00†	0†	90	70	6	6	175	150
	40FQ920 (1-Ph)	060	10.0	7.5	1	A	39.6	34.4	4†	6†	80	50	10	10	60**	60**
		120*							6†	6†	50	50				
		070	15.0	11.3	1	A	59.5	51.6	2†	2†	90	90	8	8	90	80
		130*							4†	4†	55	55				
		080	20.0	15.0	1	A	79.3	68.8	1†	1†	85	85	6	8	110	100
		140*							2†	2†	70	70				
		090	25.0	18.8	1	A	99.2	86.0	00†	0†	105	85	6	6	150	125
		150*							0‡	1‡	85	70				
		100	30.0	22.5	1	A	119.0	103.2	000†	00†	110	90	6	6	175	150
		160*							00‡	0‡	90	70				
	38HQ900131 (1-Ph)	01	10.0	7.5	1	A	39.6	34.4	4†	6†	80	50	10	10	60**	60**
									6†	6†	50	50				
		11	15.0	11.3	1	A	59.5	51.6	2†	2†	90	90	8	8	90	80
									4†	4†	55	55				
		21	20.0	15.0	1	A	79.3	68.8	1†	1†	85	85	6	8	110	100
									2†	2†	70	70				
		31	25.0	18.8	1	A	99.2	86.0	00†	0†	105	85	6	6	150	125
									0‡	1‡	85	70				

→ HEATER ELECTRICAL DATA AND USAGE (Cont)

FAN SECTION	ELECTRIC RESISTANCE HEATER (208/240 V)															
	Heater Model		Kw		No Ckts		Branch Circuit									
							Heater Amps		Min Wire Size (AWG)		Max Ft Wire		Min Gnd Wire Size		Fuse/CB Amps	
			240 V	208 V			240 V	208 V	240 V	208 V	240 V	208 V	240 V	208 V	240 V	208 V
40FS160, 40FS200, or 40FS220	40FS916320 (1-Ph)	CD	5.0	3.75	1	A	20.8	18.0	8	10	60	45	10	10	35	30
		CP	6.0	4.5	1	A	25.0	21.6	8	8	50	60	10	10	40	35
		DA	7.0	5.25	1	A	29.2	25.2	6	8	70	50	10	10	45	40
		DF	7.5	5.63	1	A	31.3	27.0	6	8	65	50	10	10	45	40
		DL	8.0	6.0	1	A	33.3	28.9	6	8	65	70	10	10	50	45
		DX	9.0	6.75	1	A	37.5	32.5	6	6	55	65	10	10	60	50
		EH	10.0	7.5	1	A	41.6	36.1	4	6	80	60	10	10	60	60
		ET††	11.0	8.25	1	A	45.8	39.7	4	6	75	55	8	10	70	60
					2	A	25.0	21.6	8	8	50	60	10	10	40	35
						B	20.8	18.0	10	10	45	55	10	10	30	25
		FE††	12.0	9.0	1	A	50.0	43.4	4	4	70	80	8	10	70	60
					2	A	29.2	25.2	6	8	70	50	10	10	45	40
						B	20.8	18.0	10	10	45	55	10	10	30	25
		FQ††	13.0	9.75	1	A	54.2	47.0	2	4	100	70	8	8	80	70
					2	A	33.3	28.9	6	6	60	70	10	10	50	45
						B	20.8	18.0	10	10	45	55	10	10	30	25
		GB††	14.0	10.5	1	A	58.3	50.5	2	4	100	70	8	8	80	70
					2	A	37.5	32.5	6	6	55	65	10	10	60	50
						B	20.8	18.0	10	10	45	55	10	10	30	25
		GM††	15.0	11.25	1	A	62.5	54.2	2	2	90	100	8	8	90	80
					2	A	41.6	36.1	4	6	80	60	10	10	60	60
						B	20.8	18.0	10	10	45	55	10	10	30	25
		GY††	16.0	12.0	1	A	66.7	57.7	2	2	80	90	8	8	90	80
					2	A	33.3	28.9	6	6	60	70	10	10	50	45
						B	33.3	28.9	6	8	70	55	10	10	45	40
		HJ††	17.0	12.75	1	A	70.8	61.3	2	2	80	90	8	8	100	90
					2	A	35.4	30.6	6	6	60	65	10	10	50	45
						B	35.4	30.6	6	8	65	50	10	10	45	40
		HV††	18.0	13.5	1	A	75.0	64.9	1	2	90	85	8	8	100	90
					2	A	37.5	32.5	6	6	55	65	10	10	60	50
						B	37.5	32.5	6	6	60	70	10	10	50	45
		JF††	19.0	14.25	1	A	79.2	68.5	2†	2	70	80	6	8	110	100
					2	A	39.6	34.3	6	8	55	60	10	10	60	50
						B	39.6	34.3	6	6	60	70	10	10	50	45
		JR††	20.0	15.0	1	A	83.3	72.2	2†	1	65	95	6	8	110	100
					2	A	41.6	36.1	4	6	80	60	10	10	60	60
						B	41.6	36.1	6	6	55	65	10	10	60	50
	40FS916500 (3-Ph)	EH	10.0	7.5	1		24.0	20.8	8†	8†	70	60	10	10	40	35
		GM	15.0	11.3	1		36.0	31.3	8†	8†	65	40	10	10	60	45
		HV	18.0	13.6	1		43.3	37.5	6†	6†	55	55	10	10	60	60
		LW	25.0	18.8	1		60.2	52.2	4	4	65	65	8	8	90	80
		PA	30.0	22.5	1		72.2	62.5	2	4	90	55	8	8	100	90

Two-stage electric heaters. Remaining heaters are single stage

CB — Circuit Breaker

*Circuit breaker models. All remaining models over 10 kw are internally fused

†Copper wire sizes based on 75 C, all other copper wire sizes based on 60 C. Copper wire is preferable

‡Copper wire rated at 75 C and no larger than 00 size must be used

**Use fuses only on 40FS916300 DL, DX, EH, 40FQ916010,020, 40FQ920060 and 40FS920300 EH units

††Standard heater models that require 2 line power circuits. Add accessory conversion lug set for single power circuit operation

NOTES:

1. Heater models 40FQ916, 40FQ920 and 40FS916320 equipped with 60-va control circuit transformer. Remaining heater models have 40-va transformer
2. Field selected wire sizes must not create a voltage drop between power source and unit in excess of 2% of unit rated voltage

Electrical data (cont)

→ **FAN SECTION DATA**

MODEL	VOLTS (1-Ph)	OPER VOLT		FLA	MCA
		Max	Min		
40FS160	208/230	253	187	3.5	4.4
40FS200				4.5	5.6
40FS220				6.9	8.6

FLA — Full Load Amps
MCA — Minimum Circuit Amps

NOTES
1. Use data in table for cooling only units. See Electric Heater Data and Usage table for heating only unit or heating cooling unit data. When fan section is equipped with heater, fan motor line power is supplied from heater line power circuit.
2. Control circuit voltage is 24 volts on all units. Accessory cooling control kit, required for cooling only units, is equipped with 40 va transformer. Transformer has adequate capacity to carry condensing unit load.

Application

All 40FS units with accessory electric heaters are suitable for installation with 0-in. clearance from heater cabinet, discharge plenum and ductwork to combustible materials with the following exceptions. When using 40FS920300PA (30 kw); all 40FQ models; 40FS916320, (11 to 20 kw) and all 40FS916500 models with 40FS200 fan section, and 40FS916500 (25 and 30 kw) with 40FS160 fan section, maintain a 1-in. minimum clearance between discharge plenum and ductwork to combustible materials for a distance of 36 in. from unit. (0-in. clearance to heater cabinet still permissible.) See 40FS Installation Instructions for details. Refer to Electrical Data table in this booklet for minimum fan speed required for safe electric heater operation.

Fan section, coil and electric heater are tested and approved for installation in unconditioned space per ARI Standards (80 F db, 75 F wb indoor temperature; 80 F db outdoor temperature). Insulate supply and return air ductwork in unconditioned space.

Sound — For acoustical treatment of ductwork, see 40FS Installation, Start-Up and Service Instructions.

Downflow — Under prolonged high humidity conditions, coil eliminator plates may be required on downflow applications.

Guide specifications

Furnish and install _____ fan section(s) equipped with (direct expansion cooling coil) (electric heater) in the location and manner shown on the plan. Assembled unit shall operate properly in (upflow) (horizontal), (downflow) position and is to be installed with ductwork. Total cooling capacity shall be _____ Btuh or greater with _____ cfm air entering cooling coil. Heating capacity shall be _____ Btuh at _____ volts or greater with _____ kw electric heater.

Fan section enclosure shall be insulated and constructed of galvanneal steel, bonderized and finished with baked enamel. The multispeed fan motor shall be factory lubricated, have internal overload protection and be resiliently mounted. The fan shall deliver _____ cfm with _____ in. wg exterenal static pressure operating at _____ fan speed. The fan motor shall not exceed _____ horsepower. Fan-motor assembly shall slide out for service. Reversible filter rack shall have duct connection flanges and be equipped with permanent-type filter that slides out for maintenance.

Cooling coil shall be constructed with aluminum plate fins mechanically bonded to nonferrous tubing with all joints brazed. Coils shall have a factory-installed refrigerant metering device and be equipped with refrigerant line fittings which permit mechanical connections. Coil casing shall be insulated and constructed of galvanneal steel, bonderized and finished with baked enamel.

Electric heater enclosure shall be insulated and have large front service access door. Heating elements shall be sequenced on and off in 5 kw increments. The 40FS models over 15 kw shall be wired for 2-stage operation. Heater shall be equipped with both thermal and current overload devices, and the required heating and cooling system controls, including (40-va) (60-va) control circuit 24-v transformer.

Maximum dimensions: length _____ in., width _____ in.; height _____ inches.

→**Accessories** shall include (Cooling Control Kit), (Heater Spacer Plate), (Return Air Plenum), (Air Cleaner), (Humidity Control Kit).

Number One
Air Conditioning
Maker

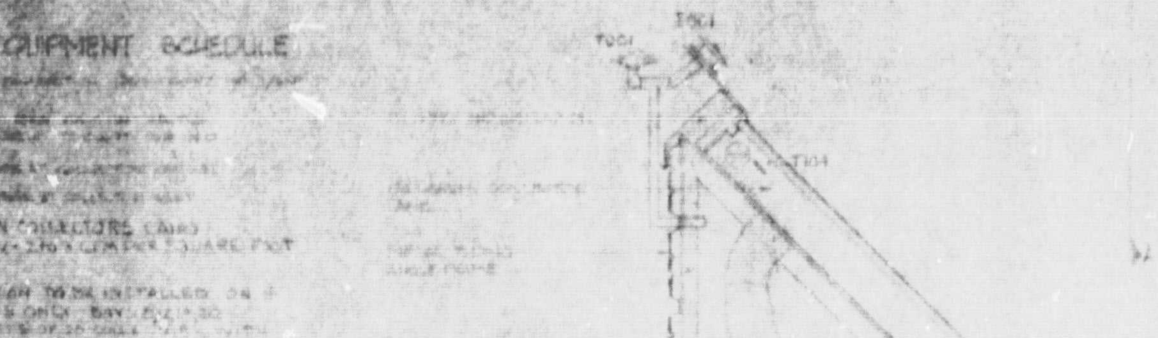
Carrier

Division of
Carrier Corporation

MECHANICAL EQUIPMENT SCHEDULE

T00 ... SOLARON COLLECTORS (AIR)
DESIGN AIRFLOW ... CFM PER SQUARE FOOT

NOTE: INSTRUMENTATION TO BE INSTALLED ON ... COLLECTOR ... ONLY ... BAY ... CONSISTS OF ... AIR HANDLER ... ELECTRIC ... DUCT SYSTEM AS SHOWN AS SYSTEM ... DIAGRAM.



3 SECTION A

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FOLDOUT FRAME

FOLDOUT FRAME 2